PB-228 616

SOUTH PLATTE RIVER BASIN WATER POLLUTION INVESTIGATION

Environmental Health Center
Cincinnati, Ohio

April 1949

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INTERIM REPORT

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SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER

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April 1949

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SOUTH PLATTE RIVER BASIN WATER POLLUTION INVESTIGATION

- INTERIM REPORT -

SYLLABUS:

This investigation was undertaken by the Environmental Health Center, Public Health Service, for the Bureau of Reclamation, Department of the Interior, in accordance with a "Memorandum of Understanding Respecting Joint Program for Stream Pollution Investigations of the South Platte River Basin", executed July 20, 1948.

Preliminary operations were started in late August, 1948, and routine operations on a basin-wide scale were underway in January 1949. This report covers operations to March 1, 1949.

The South Platte River Basin embraces some 24,030 square miles, 19,022 of which are in Colorado; 3,011 of which are in Nebraska; and 1,997 of which are in Wyoming. About 23% of the basin area lies at elevations from about 8,700 to 14,000 feet; 47% lies in the piedmont regions at elevations from 3,000 to 6,000 feet; and the remainder is in the high plains region at elevations from 6,000 to 8,000 feet.

The stream lies in a semi-arid region with average annual rainfall in the plains area of about 13 inches. Temperatures have a wide range. Relative humidities are low.

Total basin population in 1940 was 665,644, 90% of which was in Colorado, and the remainder divided about equally in Nebraska and Wyoming. Of the 1940 population, about 67% was urban and 33% was rural.

Present average annual basin water supply from all sources is about 2,800,000 acre-feet. Projects now under construction, or in the planning stage, will greatly increase the transmountain diversion supply. The Colorado-Big ThompsonProject (Exhibit I) will supply about 300,000 acre-feet, and the Blue-South Platte River Project (Exhibit II) will supply 430,000 acre-feet.

The major water usage in the basin is for irrigation. In 1940, approximately 418,000 persons were served from surface water supplies. There are 23 communities using such supplies, most of which are obtained from headwaters of streams. Twelve communities, including Denver and Cheyenne, have filter plants. The remaining 11 communities use partially treated or untreated supplies.

Approximately 540,000 persons (1940 census) are served by sewer systems discharging raw or partially treated sewage into the streams of the South Platte River system. About 5% of this number were discharging raw sewage while the sewage from the remainder received some type of treatment. Sewage from 87% of the population receives primary treatment and only 8% has secondary treatment. About 69% of the sewered population is located in the Denver area.

SYLLABUS (Continued)

Major pollution problems in the basin are those inherent in the use of sewage polluted waters for irrigation purposes, especially for those fruits or vegetables which are eaten in the raw state.

The data available at this time are not sufficient to support definite conclusions. More information is required on sources of pollution. Laboratory data are limited, and no observations have been made covering the quality of water used for irrigation purposes. No information is currently at hand from Wyoming and Nebraska or from the main stem below Kersey to North Platte or on the upper reaches of the main tributaries. However, the most serious deficiency at present is the lack of adequate epidemiological data on which to base firm conclusions regarding the public health aspects of the use of irrigation waters subject to varying amounts of pollution. Plans are now being made for the conduct of epidemiological studies in connection with this investigation.

INTRODUCTION

This investigation was undertaken as the outcome of a request from the Bureau of Reclamation to the Region 9 Office of the Public Health Service in April, 1947 to review that portion of the Blue-South Platte River Project Report dealing with the effects of pollution on the usage of waters from the South Platte River Basin. An examination into the available data on the extent, types, and degree of pollution existing in the South Platte Basin revealed that little factual data were available to substantiate any conclusions as to effects of pollution on the usage of surface waters from the South Platte River and its tributaries. Accordingly, the report submitted to the Engineer in Charge of the Blue-South Platte River Project by the Regional Office of the Public Health Service recommended that factual data be obtained as to the extent and degree of pollution currently existing in the South Platte Basin.

This recommendation was apropos to an increased interest in these regions as to the relationships between the sanitary quality of waters used for irrigation purposes and the public health hazards which may be associated therewith. Such problems, innate to the usage of polluted irrigation waters, become more acute as populations and industries increase in the semi-arid and arid regions of the west. Although these facts are realized by both reclamation and public health officials, no large scale investigations have been made to determine the extent to which waters utilized for irrigation are contaminated and to evaluate the now unknown epidemiological factors. In other words, the existence of the problem is recognized but the actual degree, extent, and exact public health significance of the condition is unknown and unsupported by factual data.

As a result of the above-mentioned preliminary investigation of the Blue-South Platte Project, subsequent contacts between the Bureau of Reclamation and the Public Health Service led to the execution of an agreement in July, 1948, whereby the Bureau of Reclamation and various public health agencies agreed to collaborate on an investigation into the pollution of the South Platte River Basin.

This interim progress report is presented in accordance with the provisions of par. 4(a) of the "Memorandum of Understanding Respecting Joint Program for Stream Pollution Investigations of the South Platte River Basin". This memorandum was executed July 20, 1948 between the U. S. Bureau of Reclamation, the Colorado State Division of Public Health, the Health Department of the City of Denver, all parties of the first part, and the Public Health Service, as party of the second part. The agreement is presented as Appendix "A". This report covers the period of operations to March 1, 1949 and by no means covers the full range of data contemplated for the final report.

ORGANIZATION, OBJECTIVES AND SURVEY METHODS

Organization: -

Under the terms of the Memorandum, the Public Health Service initiated the pollution survey of the South Platte River Basin on August 25, 1948 following the arrival in Denver, Colorado on that date of personnel from the Environmental Health Center at Cincinnati, Ohio - the Public Health Service division responsible for carrying out such operations. By December, 1948, all necessary personnel and equipment were assembled to pursue the investigation on a basin-wide scale.

Fixed laboratories were established at Denver and at Greeley in cooperation with the Colorado State Department of Public Health. A mobile laboratory unit was supplied by the Public Health Service and was placed in operation at Ft. Collins, Colorado through the courtesy of the Colorado A & M College. The Greeley laboratory and the mobile unit were staffed by Public Health Service personnel. The laboratories at Denver were those of the Colorado State Health Department. Through a cooperative agreement between the Colorado State Game and Fish Department and the Colorado State Department of Public Health, sample collectors for the Greeley and Denver laboratories were employed by the State Game and Fish Department. (See supplementary agreement, Appendix "A")

Initial stream sampling operations were begun in October 1948 in the Greeley area, utilizing personnel from the Cincinnati Station, but it was not until late December, 1948 that all of the laboratory units were functioning on a routine basis.

Objectives: -

The objectives of this survey are clearly set forth in the second par. of the Memorandum of Understanding (Appendix "A"). These objectives as stated therein are:

1. Determination of the extent, types, and major sources of pollution in the basin.

2. A review of existing state laws in Colorado, Wyoming, and Nebraska and pending legislation regarding pollution of public waters.

3. Determination of the sanitary quality of water for irrigation uses at present and at proposed diversion points and in existing canals.

4. Minimum stream flows necessary below the reservoirs for public water supplies and for sanitation purposes with present and contemplated pollution loads.

5. Public water supply needs.

6. Possible benefits to the abatement of water pollution problems by reservoir releases.

7. Recommendations and existing plans for pollution abatement.

In view of the objectives as outlined above, it was proposed to carry out the following activities in order to achieve the desired ends:

1. Determination of the extent, types, and major sources of pollution, and the sanitary quality of the water as applied to irrigation and other uses.

(a) A comprehensive sampling of the streams and diversion ditches throughout the basin at strategic locations for the purposes of determining the sanitary quality of the water as measured by the following laboratory tests:

(1) Bacterial quality as determined by the coliform test.

(2) Dissolved oxygen.

(3) Biochemical oxygen demand.

(4) Physical tests - temperature, turbidity.

(5) Chemical tests - pH, alkalinity, hardness, copper, etc.

(b) Physical inventory of all sources of pollution throughout the basin.

(c) Examination of industrial wastes where necessary to determine their effects.

(d) Stream flow records.

2. Review of state laws regarding pollution of streams.

3. Determination of minimum stream flows below reservoirs (a) for public water supplies, and (b) for sanitation purposes with present and contemplated pollution.

While not specifically mentioned in the original agreement, it is proposed also to make as extensive an epidemiological study as possible, within the limitations of time and funds. Such an investigation will be necessary in order to properly evaluate the results of the actual pollution survey work.

Methods: -

The data collected for this investigation may be divided into the following categories:

1. Data on sources and types of pollution.
2. Laboratory data.
3. Hydrometric data.

The methods used and the status of the data obtained are as follows:

Data on Sources and types of Pollution. Preliminary data have been assembled from various available sources and includes both published and unpublished materials. Data on sources of pollution are presented in Tables 1 and 2. Table 1 lists all communities in the basin showing their status with regard to sewage disposal. The basic data for this table were obtained from the "Inventory of Water and Sewage Facilities in the United States" (1945), supplemented by data from the "Nationwide Survey of Sanitation Needs" (1946). The data for Table 2 for industrial plants were obtained from a Directory of Colorado Industries published by the University of Colorado Bureau of Business Research. Production figures and quantities and strength of wastes discharged are not available at this time for industries located outside of Denver. Data on the Denver industries are presented in Appendix C. No industrial waste data are available for Wyoming and Nebraska for inclusion in this report. A detailed investigation of industrial wastes is contemplated for the coming season and will be included in the final report.

Laboratory Data. The laboratory data were obtained from physical, chemical and bacteriological tests on samples of water from about 50 points on streams in the South Platte Basin. Sampling points were located so as to give a representative picture of the water quality with respect to the area covered. Table 3 shows the number of samples examined and the number of tests made by each of the laboratories in operation to March 1, 1949. No laboratory results are available for streams in Wyoming and Nebraska as no observations were made in these areas during the period included in this progress report. Table 4 summarizes the tests made on the samples collected during the reporting period and briefly outlines reason for each test. In addition to these routine tests, special examinations were made on beet wastes from Windsor and Ft. Collins in November, 1948 in cooperation with the Great Western Sugar Co.

Laboratory determinations were made in conformance with the requirements and procedures as outlined in the "Standard Methods for the Examination of Water and Sewage" (9th edition) (1946) published jointly by the American Public Health Association and the American Water Works Association.

Hydrometric Data. Table 5 shows the summarized published flow data for the South Platte River system. This table was compiled by the U. S. Engineer Department, Denver District Office. Stream flow data for the various stream sampling stations are being supplied by the Bureau of Reclamation. The hydrometric section of the Bureau of Reclamation has installed staff gages and it is currently engaged in making measurements of stream flows at all points where reasonably accurate computations of flows are not possible. Wherever possible, sampling stations were located at or near established gaging stations. This was often possible along the main stream and near tributary mouths. Table 6 lists all gaging stations operating in the South Platte River Basin. Flow data on diversions are available from the State Engineers who are charged with

TABLE 1

SEWAGE DISPOSAL IN

SOUTH PLATTE BASIN - COLORADO - WYOMING - NEBRASKA

Community	1940 Pop.	Stream	Type of Sewers	Type of Sewage Treatment	Pop. Served
MAIN STREAM					
Colorado					
Fairplay	739	S.Platte R.	None	Individ.Systems--Privies	--
Hartsel	50	S.Platte R.	None	Individ.Systems--Privies	--
Littleton	2244	S.Platte R.	Sanitary	Imhoff Tank-Trickling Filter, Secondary Settling	1600
Englewood	9682	S.Platte R.	Sanitary	City of Denver	12000
Denver	322412	S.Platte R.	Sanitary	(1) Primary Settling, sep.sludge digestion, chlorination	
		Sand Creek	Sanitary	(2) Primary settling, sep.sludge digestion.	359400
Henderson	150	S. Platte R.	None	Individ.Systems--Privies	--
Brighton	4029	S.Platte R.	Sanitary	Primary sedimentation, sludge beds, trickling filters.	4200
Fort Lupton	1692	S.Platte R.	Sanitary	Primary sed., sep.sludge diges.,sludge beds	1615
Platteville	561	S. Platte R.	Sanitary	Non-direct to stream	365
Gilcrest	352	S.Platte R.	None	Indiv.Systems--Privies	--
LaSalle	755	S.Platte R.	Sanitary	Septic tank 40 x 8 x 8	700
Evans	800	S.Platte R.	Storm Drain	Individual Systems,pit privies. Septic tank to storm drain	250
Kersey	268	S.Platte R.	Sanitary	Lagoon 100 x 50 x 6	290
Masters	--	S.Platte R.	None	Indiv.Systems--Privies	--
Orchard	865	S.Platte R.	None	Indiv.Systems--Privies	--
Weldona	--	S.Platte R.	None	Indiv.Systems--Privies	--
Fort Morgan	4884	S.Platte R.	Sanitary	Imhoff tank - sand filters, Grit chamber	4950
Brush	2481	S.Platte R.	Sanitary	Imhoff tank	2420
Snyder	300	S.Platte R.	None	Indiv.Systems--Privies	--
Merino	259	S.Platte R.	Sanitary	None- direct to stream	207
Atwood	250	S.Platte R.	None	Indiv.Systems--Privies	--
Sterling	7411	S.Platte R.	Sanitary	Primary sed., separate sludge digestion	6705
Iliff	322	S.Platte R.	None	Indiv.Systems--Privies	--
Proctor	75	S.Platte R.	None	Indiv.Systems--Privies	--
Crook	236	S.Platte R.	None	Indiv.Systems--Privies	--
Sedgwick	373	S.Platte R.	None	Indiv.Systems--Privies	--
Ovid	687	S.Platte R.	Sanitary	None- direct to stream	675
Julesburg	1619	S.Platte R.	Sanitary	None- direct to stream	1620
Nebraska					
Barton	--	S.Platte R.	None	Indiv.Systems--Privies	--
Big Springs	569	S.Platte R.	None	Indiv.Systems--Privies	--
Brule	374	S.Platte R.	None	Indiv.Systems--Privies	--
Ogallala	3159	S.Platte R.	Sanitary	(1) No treatment	1600

TABLE 1 (Continued)

Community	1940 Pop.	Stream	Type of Sewers	Type of Sewage Treatment	Pop. Served
Nebraska					
Ogallala (Cont'd)			Sanitary	(2) Plain sed.,activated sludge, sep.diges., sludge beds 1/	2000
Roscoe	--	S.Platte R.	None	Indiv.Systems--Privies	--
Paxton	551	S.Platte R.	None	Indiv.Systems--Privies	--
N.Platte	12429	S.Platte R.	Sanitary	No treatment	15000
TRIBUTARIES					
Colorado					
Palmer Lake	269	E.Plum Creek	None	Indiv.Systems--Privies	--
Castle Rock	580	E.Plum Creek	Sanitary	Imhoff tank-sludge beds	580
Evergreen	350	Bear Creek	None	Indiv.Systems--Privies	--
Morrison	216	Bear Creek	None	Indiv.Systems--Privies	--
Federal Correctional Institution	--	Bear Creek	Sanitary	Imhoff Tank, trick filter, sludge beds	--
Fort Logan	5000	Bear Creek	Sanitary	Prim.Sed.,trickling filter, sep. sludge	3000
Parker	200	Cherry Creek	None	Indiv.Systems--Privies	--
Georgetown	391	Clear Creek	Sanitary	None - direct to stream	270
Idaho Springs	2112	Clear Creek	Sanitary	None - direct to stream	2112
Golden	3175	Clear Creek	Sanitary	None - direct to stream	3400
Westminster	534	Clear Creek	None	Indiv.Systems--Privies	--
Arvada	1500	Ralston Creek	Sanitary	Prim.Sed., sep.sludge dig.	1380
Aurora	5500	Sand Creek	Sanitary	Prim.Sed., sep.sludge dig.	5375
Buckley Field	6000	Sand Creek	Sanitary	Prim.Sed., trickling filter, sep.sludge diges., chlor.	2500
Fitzsimons	6000	Sand Creek	Sanitary	Prim.Sed.,trickling filters, sep.diges.,chlor.	--
Nederland	384	Boulder Creek	None	Indiv.Systems--Privies	--
Boulder	12958	Boulder Creek	Sanitary	Prim.sed., sep.sludge diges., chlor.	16450
Louisville	2023	Boulder Creek	None	Indiv.Systems--Privies	--
Lafayette	2052	Boulder Creek	None	Indiv.Systems--Privies	--
Frederick	652	Boulder Creek	None	Indiv.Systems--Privies	--
Dacono	296	Boulder Creek	None	Indiv.Systems--Privies	--
Coal Creek	261	Coal Creek	None	Indiv.Systems--Privies	--
Broomfield	125	Coal Creek	None	Indiv.Systems--Privies	--
Erie	1019	Coal Creek	None	Indiv.Systems--Privies	--
Lyons	654	St.Vrain Cr.	None	Indiv.Systems--Privies	--
Hygiene	250	St.Vrain Cr.	None	Indiv.Systems--Privies	--
Longmont	7406	St.Vrain Cr.	Sanitary	Prim.sed., trickling filters, sep. diges.	7600
Estes Park	994	Thompson R.	Sanitary	Prim.sed.,trickling filters, sep. diges., chlor.	850
Loveland	6145	Thompson R.	Sanitary	(1) Prim.sed.,hirate filt., sec.sed., sep.diges.	4725

TABLE 1 (Continued)

-3-

Community	1940 Pop.	Stream	Type of Sewers	Type of Sewage Treatment	Pop. Served
Colorado					
Loveland (Cont'd)			Sanitary	(2) Imhoff tank, trickling filters	1575
Johnstown	961	Thompson R.	Sanitary	None - direct to stream	1000
Millikin	531	Thompson R.	Sanitary	None - direct to stream	420
Berthoud	811	L.Thompson R.	Sanitary	Imhoff tank-trickling filt.	800
Bellvue	319	CacheLaPoudre	None	Indiv.Systems--Privies	--
Fort Collins	12251	CacheLaPoudre	Sanitary	Prim.sed.,hirate filter with circulation, sec.sed.dig., sludge beds	14250
Windsor	1811	CacheLaPoudre	Sanitary	Imhoff tank, trick.filt., sec.sed., sludge beds	1800
Greeley	15995	CacheLaPoudre	Sanitary	Chem.precip., prim.sed., sep.diges.	15300
Livermore	285	CacheLaPoudre	None	Indiv.Systems--Privies	--
Wellington	465	Boxelder Cr.	None	Indiv.Systems--Privies	--
Nunn	190	Lone Tree Cr.	None	Indiv.Systems--Privies	--
Pierce	343	Lone Tree Cr.	None	Indiv.Systems--Privies	--
Ault	761	Lone Tree Cr.	None	Indiv.Systems--Privies	--
Eaton	1322	Lone Tree Cr.	Sanitary	Septic tank 53 x 22 x 14, sand filter	1300
Galeton	200	Owl Creek	None	Indiv.Systems--Privies	--
Gill	350	Owl Creek	None	Indiv.Systems--Privies	--
Elizabeth	275	Boxelder Cr.	None	Indiv.Systems--Privies	--
Hudson	295	Boxelder Cr.	None	Indiv.Systems--Privies	--
Keenesburg	284	Boxelder Cr.	None	Indiv.Systems--Privies	--
Cheyenne,Wyoming	22474	Crow Cr.	Sanitary	Impounded in lagoons	35000
Briggsdale	250	Crow Cr.	None	Indiv.Systems--Privies	--
Cornish	140	Crow Cr.	None	Indiv.Systems--Privies	--
Roggen	110	Lost Cr.	None	Indiv.Systems--Privies	--
Elbert	325	Kiowa Cr.	None	Indiv.Systems--Privies	--
Kiowa	195	Kiowa Cr.	None	Indiv.Systems--Privies	--
Strasburg	216	Kiowa Cr.	None	Indiv.Systems--Privies	--
Wiggins	275	Kiowa Cr.	None	Indiv.Systems--Privies	--
Byers	400	Bijou Cr.	None	Indiv.Systems--Privies	--
Deer Trail	387	Bijou Cr.	Sanitary	None - direct to stream	350
Grover	137	--	None	Indiv.Systems--Privies	--
New Raymer	254	--	None	Indiv.Systems--Privies	--
Peetz	207	--	None	Indiv.Systems--Privies	--
Nebraska					
Smeed	--	Lodgepole Cr.	None	Indiv.Systems--Privies	--
Bushnell	252	Lodgepole Cr.	None	Indiv.Systems--Privies	--
Kimball	1725	Lodgepole Cr.	Sanitary	Imhoff-tric.fil.,slud.beds	1500
Dix	199	Lodgepole Cr.	None	Indiv.Systems--Privies	--
Potter	387	Lodgepole Cr.	None	Indiv.Systems--Privies	--
Brownson	--	Lodgepole Cr.	None	Indiv.Systems--Privies	--
Sidney	3388	Lodgepole Cr.	Sanitary	Imhoff-trick.fil.,slud.beds	3000
Chappell	1093	Cow Creek	Sanitary	Imhoff-sand filt.,slud.beds	1000

1/ Plant not operating.

TABLE 2

Partial List of Industrial Wastes
South Platte River Basin - Colorado, excluding Denver

Industry	Number of Plants
FOOD AND KINDRED PRODUCTS	
Beet Sugar	13
Beverages, Alcoholic	
Distillery	1
Brewery	1
Beverages, Non-Alcoholic	9
Butter and Ice Cream	15
Canneries	11
Cheese	2
Confectionary	1
Evaporated and Condensed Milk	2
Flour Mills	4
Malted Milk Powder	1
Meat Products	6
Pickled Products and Prepared Sauces	2
Potato Chips	6
Prepared Feeds for Animals	6
CHEMICALS AND ALLIED PRODUCTS	
Automotive Chemicals	1
Cellulose	1
Drugs and Medicine	1
Fertilizers	1
Industrial Chemicals	1
Insecticides	2
Rendering Plants	4
IRON AND STEEL	
Foundries	1
NON-FERROUS METALS	
Plating	1

TABLE 3

Sampling at Various Laboratories
South Platte River Basin Water
Pollution Investigation

Laboratory Location	Operations began -date-	Streams Covered	No. Samples examined to 3-1-49	No. Determinations made to March 1, 1949
Greeley, Colo. (Greeley Sewage Treatment Plant)	10-19-48	So.Platte River Cache LaPoudre Thompson Little Thompson	405	2,016
Ft. Collins (Trailer Unit)	1-6-49	Cache LaPoudre St. Vrain Thompson Boulder Timnath Reservoir Fossil Creek Res.	98	573
Denver (State Health Dept. Labs)	12-22-48	Bear Creek So.Platte River Clear Creek Burlington Ditch Barr Lake Inlet	154	708
TOTALS			657	3,297

TABLE 4

Various Physical, Chemical and Bacteriological Examinations Used In South Platte River Basin Water Pollution Investigation

TEST	REASON
	Physical and Chemical
1. Temperature	Influences solubility of oxygen and rate of self-purification.
2. Turbidity	Index of silt or other suspended matter density.
3. pH	A measure of the concentration of hydrogen ions in the water.
4. Alkalinity	Represents content of carbonates, bicarbonates, hydroxides and sometimes borates, silicates and phosphates.
5. Soap Hardness	Measures the soap consuming power of the water. Gives a rough measure of the concentration of hardness producing minerals (principally calcium and magnesium) in the water.
6. Dissolved Oxygen	Necessary to natural purification of streams and essential for fish and other aquatic life. Supports biochemical oxidation of organic wastes. Is replaced by absorption from atmosphere or from photosynthetic action of some water plants, including algae. Polluting organic substances which absorb oxygen from the stream depress the dissolved oxygen below the saturation level. The degree of this depression is a measure of the deoxygenation effect of the polluting matter and is therefore a measure of the degree of pollution present.
7. 5-day BOD at 20°C	Indicates the amount of dissolved oxygen which may expect to be absorbed from the stream water in 5 days at 20°C in order to support the biochemical oxidation of the organic pollution carried by the stream at the point of sampling. (BOD = Biochemical Oxygen Demand).
8. Copper	The presence of this metal in significant amounts affects the biochemical oxygen demand (BOD) by limiting biological growths.
	Bacteriological
9. Coliform bacteria (determined by standard confirmed fermentation tube test at 37°C)	This test is the most delicate and specific test for pollution by sewage as it shows the approximate density of a group of bacteria which are always present in large numbers in sewage and are relatively few in numbers in other stream pollutants. Coliform bacteria are normal inhabitants of the intestinal tracts of warm blooded animals and are discharged in large numbers in human feces, which constitute the principal source of these bacteria in sewage.

TABLE 5. Summary of Published Stream Flow Data for the South Platte River and Tributaries.

Stream	Station	Mile-age	Drain-age area	Maximum peak discharge		Minimum mean daily dis-charge	Annual Runoff		
							maximum	minimum	mean
			sq.mi.	sec.-ft.	date	second-feet	acre-feet	acre-feet	acre-feet
South Platte River	Near L. George	384.0	929	990	8-15-30	8.0	108,000	10,270	62,630
	Lake Cheesman	361.5	1,730	3,030	4-23-42	6.5	242,300	35,300	126,940
	Waterton	327.4	2,611	5,700	4-23-42	0.1	513,900	41,530	134,010
	Denver	302.3	3,840	22,000	9-10-33	15.0	801,600	103,900	266,600
	Henderson	286.7	4,792	10,700	4-26-42	6.0	844,000	115,300	242,970
	Ft. Lupton	272.2	5,108	9,000	4-26-42	10.0	877,500	113,100	251,380
	Kersey	231.9	9,500	31,000	6- 7-21	35.0	1,435,000	181,470	560,650
	Sublette	210.0	12,269	30,000*	6- 7-21	--	420,200	93,840	231,060
	Balzac	164.1	17,194	**	5-31-35	4.6	1,030,000	69,000	278,260
	Julesburg	90.2	22,800	31,300	6- 2-35	0.0	1,092,000	61,790	323,700
	N.Platte,Nebr.	0.0	24,030	37,100	6- 3-35	0.0	1,055,000	56,360	377,530
Bear Creek	Morrison,Colo.	11.5	165	8,600	7-24-96	0.8	90,560	13,640	43,580
	Mouth	0.75	265	3,000	7- 7-33	0.7	98,490	5,440	27,820
Clear Creek	Golden, Colo.	18.0	414	8,700	8- 1-88	18.0	278,800	109,900	176,260
	Mouth	0.8	600	3,650	9- 3-38	0.9	118,450	20,900	60,770
St.Vrain Cr.	Lyons, Colo.	36.6	266	10,500	6-22-41	0.0	145,200	51,500	96,490
	Mouth	2.7	1,000	11,300	9- 3-38	12.0	343,770	40,000	130,310
Boulder Cr.	Orodell,Colo.	27.7	105	2,500	6- 6-21	1.5	100,700	37,300	67,700
	Mouth	0.0	485	4,410	9- 3-38	0.0	149,420	3,230	40,420
Big Thompson River	Canon mouth near Drake	39.7	308	5,600	9- 1-38	7.0	150,230	83,350	128,750
	Mouth	0.2	842	3,000	9- 3-38	0.0	48,440	12,560	34,890
CacheLaPoudre River	Canon mouth	59.4	1,048	**	5-20-04	3.0	381,400	135,200	303,450
	Mouth	1.1	1,840	4,240	6-24-17	2.3	100,400	20,270	68,300

* Approximate **Not determined

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TABLE 6

STREAM GAGING STATIONS IN OPERATION
SOUTH PLATTE BASIN

Stream and Station	Drainage area a/	Record began
South Platte above Elevenmile Reservoir	861	1939
South Platte near Lake George	929	1929
South Platte above Lake Cheesman	1,680	1924
South Platte below Lake Cheesman	1,766	1924
South Platte at South Platte below North Fork	2,550	1902
South Platte at Waterton	2,621	1926
South Platte at Littleton	3,090	1941
South Platte at Denver b/	3,840	1895
South Platte at Henderson	4,740	1926
South Platte at Ft. Lupton	5,070	1906
South Platte at Kersey	9,500	1901
South Platte at Sublette	12,900	1926
South Platte at Ft. Morgan	14,800	1943
South Platte at Balzac	17,700	1914
South Platte at Julesburg	22,800	1902
South Platte at Ogallala, Nebraska	23,500	1931
South Platte at Paxton, Nebraska	23,700	1939
South Platte at North Platte, Nebraska	24,300	1914
Tarryall Creek near Lake George (near mouth)	460	1910
Goose Creek above Lake Cheesman	86	1909
North Fork of South Platte at Grant below Geneva Creek	130	1942
North Fork of South Platte at Pine	374	1942
North Fork of South Platte at South Platte	484	1909
Deer Creek near Littleton	22	1942
Plum Creek near Sedalia	273	1942
Turkey Creek near Morrison	49	1942
Bear Creek at Morrison	165	1888
Bear Creek at mouth	265	1914
West Fork of Clear Creek above Empire	40	1929
Clear Creek below Lawson	...	1946
Clear Creek near Golden	392	1908
Clear Creek at mouth near Derby	600	1914
Cherry Creek near Franktown	172	1939
Cherry Creek near Melvin	369	1939
Cherry Creek at Denver	420	1942
South Boulder Creek near Eldorado Springs	114	1888
Boulder Creek near Orodell	105	1887
Fourmile Creek near Boulder c/	...	....
Boulder Creek at mouth near Longmont	512	1927
St. Vrain Creek at Lyons	226	1887
Lefthand Creek near Boulder d/	48	1929
St. Vrain Creek at mouth near Platteville	1,000	1915
Little Thompson above irrigation (above Ish Ditch) c/	...	....

TABLE 6 (Continued)

-2-

Stream and Station	Drainage area a/	Record began
Glacier Creek above Estes Park c/	...	....
Fall River above Estes Park c/	...	....
Big Thompson at Estes Park	158	1930
Fish Creek near Estes Park c/	...	....
North Fork of Thompson below Estes c/	...	....
Big Thompson below power house near Drake	277	1928
Big Thompson at canyon mouth near Drake	302	1917
Cottonwood Creek near Drake c/	...	....
Buckhorn Creek near Masonville c/	...	....
Big Thompson at mouth near LaSalle	818	1914
Cache La Poudre at canyon mouth	1,048	1881
Cache La Poudre near mouth near Greeley	1,840	1903
North Fork of Crow Creek near Hecla, Wyoming	27	1933
Middle Fork of Crow Creek near Hecla, Wyoming	23	1933
South Fork of Crow Creek near Hecla, Wyoming	16	1933
Boxelder Creek near Hudson, Colorado	...	1942
Lodge Pole Creek at Bushnell, Nebraska	1,090	1931

a/ Drainage areas are in square miles.
b/ Records continuous since May 7, 1895.
c/ Installed in late 1947. No data available at this date.
d/ Re-installed in late 1947. No further data available at this date.

TABLE 7

River Mileages, Drainage Areas, Channel Elevations and Slopes

Location	Miles above mouth		Drainage area square miles	Elevations feet above mean sea level	Slope feet per mile
	Main Stream	Tribs.			
Main Stem of South Platte River					
Source	442.2			13,300	
Fairplay, Colorado	423.8		83	9,900	184.8
Mouth of South Fork	402.3			8,980	42.8
Mouth of Tarryall Creek	363.7			7,410	40.7
South Platte, Colorado	335.6		2,550	6,078	47.4
Waterton, Colorado (gage)	327.4		2,611	5,484	72.4
Chatfield damsite	320.6		2,988	5,388	14.1
Littleton, Colo. (gage)	314.4		3,090	5,305	13.4
Denver,Colo.(19th St.gage)	302.3		3,840	5,162	11.8
Henderson, Colo. (gage)	286.7		4,792	5,005	10.1
Ft. Lupton, Colo. (gage)	272.2		5,108	4,889	8.0
End of proposed levee system (near mouth St. Vrain Creek)	252.1			4,727	8.1
Kersey, Colorado (gage)	231.9		9,500	4,575	7.5
Sublette, Colo. (gage)	210.0		12,269	4,420	7.1
Narrows damsite	192.5		13,397	4,310	6.3
Fort Morgan damsite	187.3		14,894	4,274	6.9
Balzac, Colorado (gage)	164.1		17,194	4,090	7.9
Ovid, Colorado (gage)	90.2			3,502	8.0
Mouth	0.0		24,030	2,790	7.9
Tributary Streams					
South Fork					
Source		33.0		11,900	
Above Lake Antero		20.3		9,060	139.9
Mouth	402.3	0	225	8,980	6.3
Tarryall Creek					
Source		48.4		11,950	
Mouth	363.7	0	460	7,410	93.8
N.Fork of South Platte R.					
Source		47.4		12,580	
Grant, Colorado		36.4	125	8,566	364.9
Cassells, Colorado		34.4	133	8,500	33.0
So.Platte, Colo. (gage)		0.3	484	6,091	70.6
Mouth	335.6	0	484	6,080	36.7
Plum Creek					
Source		43.1		8,500	
Castle Rock, Colorado		29.3		6,790	123.9
Sedalia, Colorado		9.5	273	5,723	53.9
Mouth	320.9	0	324	5,388	35.3

TABLE 7 (Continued)

Location	Miles above mouth		Drainage area square miles	Elevations feet above mean sea level	Slope feet per mile
	Main Stream	Tribs.			
Bear Creek					
Source		44.0		12,740	
Near Brookvale		29.7		7,500	366.4
Morrison, Colorado		10.8	165	5,781	91.0
Mount Carbon damsite		8.2	236	5,520	100.3
Mouth	311.3	0	265	5,283	28.9
Little Dry Creek					
Source		15.1		6,000	
Little Dry Creek Dam		9.5	9.5	5,580	75.0
Englewood, Colorado (Clarkson Street)		2.5		5,325	36.4
Mouth	310.5	0	24.0	5,265	24.0
Cherry Creek					
Source		68.0		7,630	
Near Table Rock		63.6		7,220	93.2
Near West Fork		46.9		6,585	38.0
Old Castlewood Damsite		40.7	168	6,370	34.7
Franktown, Colo.(gage)		39.0	172	6,148	130.6
Kenwood Dam		11.4	386	5,491	25.9
Mouth	302.8	0	414	5,168	28.3
Clear Creek					
Source		67.0		12,200	
Silver Plume, Colo.		52.9		8,500	262.4
Golden, Colo. (gage)		17.7	414	5,735	78.6
Below Golden		14.0		5,525	56.8
Mouth	296.0	0	600	5,110	29.6
St.Vrain Creek System					
St. Vrain Creek					
Source		61.4		12,400	
Lyons, Colo. (gage)		33.4	266	5,349	251.8
Mouth	253.4	0	1,000	4,740	18.2
Boulder Creek					
Source		51.4		12,000	
Barker Reservoir		34.5		7,780	247.9
Near Boulder (gage)		27.3	137	5,500	316.7
Above Boulder, Colo.		20.0	143	5,280	30.1
Mouth	270.0	0	485	4,800	24.0
Coal Creek					
Source		30.7		8,887	
Near Coal Creek Peak		20.5		6,000	283.0
Superior, Colorado		10.5		5,270	73.0
Erie, Colorado		3.0	81.5	5,005	35.3
Mouth	277.5	0	83.6	4,955	16.7

TABLE 7 (Continued)

Location	Miles above mouth		Drainage area square miles	Elevations feet above mean sea level	Slope feet per mile
	Main Stream	Tribs.			
Big Thompson River					
Source		79.0		11,000	
Near Estes Park		68.9	158	8,500	247.5
Near Prospect		52.5		7,000	91.5
Mouth of Canyon (gage)		40.1	308	5,400	129.0
Near Cedar Grove		37.1		5,095	101.7
Mouth	244.9	0	842	4,660	11.7
Cache la Poudre River					
Source		121.3		10,700	
Near Barnes-Meadow Reservoir		99.9		8,000	126.2
Near Ft. Collins Nat'l Park		56.1		5,225	63.4
Mouth of Canyon (gage)		49.9	1,048	5,070	25.0
Mouth	233.9	0	1,840	4,610	9.2
Crow Creek					
Source		140.0		8,600	
Above Cheyenne Reservoir		128.2		6,775	154.7
At Hecla, Wyoming		126.2		6,720	27.5
Silver Crown, Wyoming		119.9		6,400	50.8
Mouth	227.8	0	1,515	4,572	15.2
Kiowa Creek					
Source		114.5		7,500	
Near Elbert, Colorado		99.0		6,765	47.4
Near Sand Creek Reservoir		38.5		5,000	29.2
Mouth	203.0	0	760	4,380	16.1
Bijou Creek					
Source		116.4		7,200	
Near Kuhn's Crossing		99.0		6,000	69.0
Near Agate		88.9		5,000	99.0
Mouth	189.5	0	1,462	4,280	8.1
Beaver Creek					
Source		90.9		5,500	
Near Middlemist Reservoir		64.6		5,000	19.0
Mouth	170.4	0	1,301	4,130	13.5
Lodgepole Creek					
Source		215.8		8,500	
Near Cheyenne Pass		210.0		7,780	124.1
Near Islay		204.8		7,500	53.8
Near Islay		201.8		6,640	286.7
South Fork		169.3		5,725	28.2
Sidney, Nebraska		51.0		4,100	13.7
Mouth	90.0	0	3,101	3,500	11.8

the distribution of the waters in accordance with the adjudicated decrees governing diversions of surface waters.

The stream flow data for the sampling period to March 1, 1949 were not available in time for inclusion in this interim report.

DESCRIPTION OF BASIN

The South Platte River arises in the extensive high, precipitous front ranges of the Rocky Mountains in Colorado, and flows for approximately 450 miles in a northerly and easterly direction to its confluence with the North Platte River at North Platte, Nebraska. The drainage area embraces 24,030 square miles of which 19,022 are in Colorado, 3,011 are in Nebraska, and 1,997 are in Wyoming. Approximately 5,550 square miles of the basin (23%) lie in the mountain regions at elevations varying from 8,700 feet to over 14,000 feet; 11,340 square miles (47%) lie in the piedmont regions at elevations of 3,000 to 6,000 feet; and the remaining 7,140 square miles (30%) of the basin lie in the high plains regions at elevations varying from 6,000 to 8,000 feet above mean sea level. Figure 1 shows the drainage area of the South Platte River Basin.

Stream velocities are swift as stream slopes are relatively steep. In the mountainous regions the slopes on the main stem and tributaries vary from maximums of over 1,000 feet per mile to minimums of about 20 feet per mile. The average slope of the main stream in the plains area is about 8 feet per mile, with a maximum of 15 feet per mile immediately below Denver. Tributary streams arising in the plains area have average slopes varying from about 70 feet per mile near their sources, to about 14 feet per mile near their mouths. All tributaries draining the mountain regions are perennial streams which contribute heavily to the regular flow of the main stream. Plains tributaries are intermittent streams, but are often important contributors to spring and summer runoff. Mean annual recorded runoff of the South Platte River system at North Platte, Nebraska, is approximately 380,000 acre feet. Table 7 compiled by U. S. Engineer Department, Denver Office, shows river mileages, drainage areas, channel elevations and slopes. These figures were used in computation of all stream mileage estimates.

Climatic Conditions in the Basin: -

The basin lies within the semi-arid plains region. The minimum average annual rainfall within the basin, excepting the South Park area, is 12.35 inches at Greeley, Colorado. The average annual rainfall at Hartsel in the South Park area is 10.77 inches. The maximum average rainfall occurs in the mountain regions, with 30.82 inches at Silver Lake, Colorado.

Table 8 presents the monthly distribution of precipitation in percentage of the average annual precipitation for representative weather stations in the South Platte River basin and adjacent west slope diversion areas.

TABLE 8

Monthly Precipitation in Percentage of Average Annual Precipitation

Station	Elevation	Months											
		J	F	M	A	M	J	J	A	S	O	N	D
Cheyenne, Wyoming	6,088	3	4	7	13	16	11	14	11	8	6	4	3
Kimball, Nebraska	4,697	3	4	6	13	16	15	14	11	7	5	3	3
Ft. Collins, Colo.	5,003	3	4	7	14	18	11	11	9	9	8	3	3
Greeley, Colorado	4,648	2	3	6	13	19	12	14	9	8	8	3	3
Boulder, Colorado	5,404	2	4	9	15	16	9	12	8	8	9	4	4
Denver, Colorado	5,221	3	4	8	15	17	9	11	10	7	7	4	5
Calhan, Colorado	6,508	2	3	5	11	13	10	17	18	9	5	3	4
Sterling, Colorado	3,939	2	2	5	13	17	15	11	12	9	7	3	4
Ft. Morgan, Colorado	4,321	2	2	5	14	17	13	17	11	8	6	3	2
Sedgwick, Colorado	3,583	2	2	5	13	15	16	15	13	8	6	2	3
Hartsel, Colorado	8,860	2	3	4	7	8	10	25	20	10	5	3	3
Cheesman, Colorado	6,890	2	3	6	13	12	9	18	15	9	6	3	4
Kassler, Colorado	5,495	3	4	8	15	14	9	11	10	8	8	5	5
Idaho Springs, Colo.	7,556	2	3	6	13	12	9	18	14	9	8	3	3
Silver Lake, Colo.	10,200	6	9	11	13	9	8	12	7	7	6	6	6
Longs Peak, Colorado	9,240	3	6	9	13	12	8	16	10	8	7	4	4
Fry's Ranch, Colo.	7,400	3	5	7	13	12	8	14	9	9	9	5	6
Grand Lake, Colorado	8,380	10	13	7	12	7	6	11	9	6	6	5	8
Dillon, Colorado	8,900	7	9	11	11	9	6	11	9	7	7	6	7
Green Mtn.Dam, Colo.	7,760	6	7	10	13	10	9	8	9	6	9	7	6

The snowfall in the South Platte River basin is generally light except in the mountains. The greatest amount of snow falls during March in plains areas and during April in the mountains. Table 9 presents the minimum, maximum and mean annual snowfalls at representative weather stations in the basin, and the greatest recorded depth of snowfall on the ground.

TABLE 9

Snowfall Data for South Platte River Basin.

Station	Years of Record	Average annual snowfall			Greatest depth of snowfall on the ground	
		Minimum inches	Maximum inches	Mean inches	inches	date
Boulder, Colorado	51	36.5	122.2	68.7	24.7	12-19-1911
Cheesman, Colo.	43	17.4	94.5	54.5	43.0	5 - 1913
Denver, Colorado	61	17.9	115.9	55.7	32.6	12- 5-1913
Estes Park, Colo.	36	41.8	193.0	102.0	48.0	12- 5-1913
Ft.Collins, Colo.	69	6.1	67.8	39.3	26.0	2- 2-1883
Ft.Morgan, Colo.	50	7.3	49.9	25.8	18.0	2-29-1912
Greeley, Colorado	54	4.9	76.2	31.0	26.0	4-19-1920
Idaho Springs,Colo.	45	36.5	132.3	70.3	51.0	12- 5-1913
Julesburg, Colo.	38	6.9	63.3	28.3	12.0	4-14-1927
Kassler, Colorado	42	16.0	101.5	67.6	55.0	12- 8-1913
Longs Peak, Colo.	51	65.7	274.6	147.6	36.0	10-25-1923
Sedgwick, Colo.	40	4.7	73.3	29.2	12.0	3-11-1912
Sterling, Colo.	37	7.0	58.0	32.6	13.0	12-14-1940
Grand Lake, Colo.	10	77.5	179.3	121.5	----	----
Dillon, Colorado	37	65.8	205.5	121.4		

Snow surveys have been made for the past ten years at sixteen snow courses in the South Platte River basin by the U. S. Department of Agriculture and the Colorado Agricultural Experimental Station, Ft. Collins, Colorado, in cooperation with other federal, state and local agencies. All of these snow courses are above elevation 8,600 feet and eleven are above elevation 10,000 feet. The ten year average snow depth and water content on the ground on April 1st in the major watersheds in the basin were computed from the results of those surveys and are presented in Table 10.

TABLE 10

Average Snow Depth and Water Content on April 1.

Watershed	Average snow depth inches	Average water content inches
South Platte River above Denver	22.3	5.9
Crow Creek	16.0	4.5
Cache la Poudre River	40.9	12.6
St. Vrain Creek	44.4	13.2
Boulder Creek	39.6	11.2
Clear Creek	49.6	14.8

There is a wide range of temperatures. In winter, the average monthly mean temperatures are highest near the mountains. Recorded extreme temperatures from various stations in the basin show highs in excess of 100°F. and lows of about -40°F.

Table 11 gives the maximum and minimum recorded, average maximum, average minimum, and average mean annual temperatures for representative weather stations in the basin in Colorado.

TABLE 11

Average Annual and Extreme Temperatures.

Station	Years of record	Extreme temperatures		Average annual temperatures		
		Maximum	Minimum	Maximum	Minimum	Mean
Boulder, Colorado	49	102	-33	63.1	38.1	50.6
Cheesman, Colorado	42	99	-35	62.4	30.5	46.5
Denver, Colorado	73	105	-29	63.0	37.8	50.4
Estes Park, Colorado	29	98	-35	55.4	28.7	42.2
Ft. Collins, Colorado	65	104	-38	61.6	33.1	47.0
Ft. Morgan, Colorado	48	109	-36	63.2	32.5	47.9
Greeley, Colorado	52	107	-45	64.2	31.9	48.1
Idaho Springs, Colo.	46	93	-29	56.3	30.5	43.3
Julesburg, Colo.	32	108	-38	64.6	34.3	49.5
Kassler, Colorado	31	103	-32	66.4	36.5	51.5
Sedgwick, Colo.	33	113	-40	64.8	33.6	49.3
Longs Peak, Colo.	48	94	-41	50.5	24.6	37.5
Sterling, Colorado	35	104	-33	63.7	33.1	48.4
Grand Lake, Colo.	10	87	-38	--	--	36.4
Dillon, Colorado	37	89	-46	--	--	34.3
Green Mtn.Dam, Colo.	13	89	-40	--	--	40.2

The average growing season, the period free from killing frost, in the lower portion of the basin is 145 days and increases to 163 days at Denver and 165 days at Boulder. The shortest growing season in the plains area was 81 days at Fort Morgan in 1918, and the longest was 260 days at Boulder in 1901, which appears to be an extreme as the next longest growing season was 204 days at Denver in 1933. The average growing season in the mountains at Long's Peak is 61 days, where the shortest growing season of record was 3 days in 1910.

Relative humidities are low in the plains region, the annual average at Denver being 42 - 63 per cent. Evaporation at Fort Collins, Colorado, shows an average monthly rate varying from 1.30 inches in December, to 6.23 inches in July.

Population: -

The total population in the basin in 1940 was 665,644, of which 602,074 or 90%, were in Colorado; 31,149 were in Nebraska; and 32,421 were in Wyoming. Of the total basin population in 1940, 67% was urban and 33% was rural living on farms or in towns of 2500 or less. The density of population in the basin, excluding Denver, North Platte, and Cheyenne, is 14.8 persons per square mile in Colorado, 8.6 per square mile in Nebraska, and 5.0 per square mile in Wyoming. Table 12 shows the population growth of cities in the South Platte Basin for the period 1900 to 1940. Table 13 shows the comparative growth of urban, rural, and farm populations in the basin for the period from 1900 to 1940.

TABLE 12

Populations of Cities in the South Platte River Basin from 1900 - 1940

Location	Census Year				
	1940	1930	1920	1910	1900
Colorado:					
Boulder	12,958	11,223	11,006	9,539	6,150
Brighton	4,029	3,394	2,715	850	366
Brush	2,481	2,312	2,103	997	381
Denver	322,412	287,861	256,491	213,381	133,859
Englewood	9,680	7,980	4,356	2,983	---
Ft. Collins	12,251	11,489	8,755	8,210	3,053
Ft. Morgan	4,884	4,423	3,818	2,800	634
Golden	3,175	2,426	2,135	2,477	2,152
Greeley	15,995	12,203	10,958	8,179	3,023
Julesburg	1,619	1,467	1,320	962	371
Littleton	2,244	2,019	1,626	1,373	738
Longmont	7,406	6,029	5,848	4,256	2,201
Loveland	6,145	5,506	5,065	3,651	1,091
Sterling	7,411	7,195	6,415	3,044	998
Nebraska:					
Kimball	1,725	1,711	1,620	454	254
North Platte	12,428	12,061	10,466	4,793	3,640
Ogallala	3,159	1,631	1,062	643	355
Sidney	3,388	3,306	2,852	1,185	1,001
Wyoming					
Cheyenne	22,474	17,361	13,829	11,320	14,087

TABLE 13

Comparative Growth of Urban, Rural and Farm Populations in the South Platte River Basin 1900 - 1940

Year	Urban		Rural		Total	
	Number	Percent increase	Number	Percent increase	Number	Percent increase
1900	167,608	---	95,279	---	262,887	---
1910	269,755	60.9	137,550	44.4	407,305	54.9
1920	337,341	25.1	172,034	25.1	509,375	25.1
1925	-----	--	----	---	---	---
1930	384,000	13.8	201,887	17.4	585,887	15.0
1940	445,018	15.9	220,626	9.3	665,644	13.6

Economic Conditions in the Basin: -

Agricultural development. Agriculture, including the raising of livestock, has been a primary activity in the basin and only in recent years has contested for first place with the manufacturing industry. The principal crops grown in the South Platte River basin in the order of value are hay and forage, wheat, sugar beets, potatoes, barley, dry beans, corn, oats, rye, sorghums and other grains, and seed. The Nebraska portion of the basin normally produces nearly half of the wheat in the basin and about one third of the corn. Of the other crops mentioned, the Nebraska and Wyoming portions of the basin produce percentages roughly corresponding to the proportional areas of those states in the basin. The mean total value of the principal crops produced in the Colorado portion of the basin between 1930 and 1940 was $33,050,000. Crop production in the past, based on crop values, shows a very slightly upward trend. Truck farming, on the other hand, has shown a decided upward trend, both in values and acreage, corresponding roughly to the population trend of the city of Denver. Most of the truck farming in the basin is carried on in the vicinity of Denver and in the Northern Colorado area. Shipments of truck produce to areas outside of the basin are increasing from year to year. Table 14 presents the values of crops produced in the South Platte River basin in 1939 and shows the distribution of those crops in the different parts of the basin.

TABLE 14

Values of Crops Produced in South Platte River Basin in 1939

Crop	Entire basin	Colorado portion of basin	Nebraska portion of basin	Wyoming portion of basin
Hay and forage	$ 6,590,800	$ 6,081,700	$ 428,300	$ 80,800
Wheat	6,525,000	3,885,300	2,606,300	33,400
Sugar beets	5,807,200	5,627,400	177,400	2,400
Potatoes	2,818,800	2,533,000	254,800	31,000
Barley	2,447,800	2,292,800	152,600	2,400
Beans (dry)	2,227,800	2,218,800	9,000	0
Corn	1,292,900	775,000	492,100	25,800
Oats	425,200	359,300	62,700	3,200
Rye	112,300	52,900	56,500	2,900
Sorghum(grain)	33,500	14,000	19,400	100
Grains (mixed)	26,800	14,400	12,400	0
Totals	$28,308,100	$23,854,600	$4,271,500	$182,000

Irrigated and non-irrigated crops. The South Platte River basin lies in a semi-arid region and depends largely on irrigation for its agricultural wealth. Although a considerable portion of the arable land is devoted to dry farming, the greater percentage of the production is from irrigated land. The value of irrigation is strikingly shown in Table 15 which presents a comparison of yields per acre for various crops on irrigated and dry farms in Colorado and Nebraska.

TABLE 15

Comparison of Yields on Irrigated and Non-irrigated Land.

Crop	Unit	Colorado		Nebraska		Entire basin	
		Irrigated	Dry	Irrigated	Dry	Irrigated	Dry
Corn	Bu	26.6	5.5	28.6	8.9	26.9	7.7
Oats	Bu	33.1	10.8	29.2	15.2	32.9	13.1
Barley	Bu	34.4	6.8	33.7	13.0	34.4	8.8
Rye	Bu	17.7	6.1	15.3	10.4	17.5	8.9
Wheat	Bu	22.8	8.9	15.9	12.8	22.8	10.8
Sorghums (grain)	Bu	10.3	5.4	15.3	8.4	10.8	6.8
Beans	Bu	20.9	2.5	12.1	3.3	20.9	2.5
Potatoes	Bu	205.3	22.2	169.8	35.8	201.0	34.5
Sorghums (forage)	Tons	1.6	0.5	1.3	1.1	1.6	0.7
Alfalfa	Tons	2.0	1.1	2.2	1.4	2.0	1.2
Other:							
Tame Hay	Tons	1.1	0.7	0.7	0.9	1.0	0.7
Wild Hay	Tons	0.7	0.7	0.9	0.7	0.7	0.7

Wyoming yields are omitted from this table because of the small acreages involved, and truck crops are omitted because they.cannot be raised on non-irrigated land in this region. In 1939 the crops produced on irrigated land were valued at $21,850,700 (73 percent of total), although only 34 percent of the total land under cultivation was irrigated. The total area under irrigation in the basin in 1939 was approximately 1,200,000 acres, 96 percent of which was in the Colorado portion and 3 percent in the Nebraska portion. The acreage under irrigation being a function of the annual water supply, there has been no increase in irrigated acreage in the basin for some time because all of the available surface water was appropriated by the early part of the century. The construction of the Colorado-Big Thompson Project will greatly increase the water available for irrigation in the area below Platteville, and the Blue-South Platte Project now under consideration proposes to augment the water resources from the North Fork to Platteville and eastward to Kiowa Creek.

Livestock. The livestock industry is one of the oldest in the basin, ranking second in age only to mining. Settlement and fencing of the range lands have brought about a general decrease in livestock raising in the past several decades, but it is still a major industry, furnishing the raw product for many large factories and packing plants in the area. The livestock raised in the basin includes beef and dairy cattle, sheep, swine, horses, mules, goats and poultry. Cattle have consistently ranked first in value among domestic animals. The total value of all livestock in the basin on April 1, 1940 was $23,697,000 distributed as follows: Colorado, $18,933,000, or 80 %; Nebraska, $2,748,000; and Wyoming, $2,016,000. The total includes an aggregate of $15,663,800 for cattle, $4,300,800 for horses and mules, $2,512,600 for sheep, and $596,400 for swine.

The dairying industry ranks as one of the more important in the basin and includes butter and cheese manufactured on the farm and in factories, whole and evaporated milk, ice cream and similar products. Poultry including chickens, turkeys, ducks and geese is raised on the farm and in a large number of establishments engaged in the business on a considerable scale. Honey produced in the basin commands top prices on eastern markets. Livestock products, including wool, for the basin in 1939 had an aggregate value of $9,166,740 of which $8,112,730 (88%) was produced in Colorado, $701,920 in Nebraska, and $352,090 in Wyoming. These figures are exclusive of animals butchered on the farm and those killed and sold locally for which federal census figures give an additional $18,739,000, bringing the total income for livestock butchered and livestock products to $27,905,740 for that year.

Industrial Development. The industrial development of the South Platte River basin, although highly diversified, is not on a large scale; the rural districts being devoted more to agricultural pursuits, and the larger cities and towns to educational and resort purposes. Denver is the manufacturing center not only for the South Platte River basin but for a large portion of the Rocky Mountain area. However, sugar factories, canneries for fruits, vegetables and milk, and mills for flour and other grains are located in and near farm centers throughout the agricultural region. The aggregate of values added to raw materials by industrial processing in the South Platte River basin for the year 1939 was $65,329,200, of which $48,678,990 was due to Denver manufacturing. The major divisions of food and allied products are meat packing, poultry dressing, baking, sugar, and canning. Included in miscellaneous are the ceramic, rubber, apparel, explosives, lumber and timber products industries.

Mining. The mining industry ranks third in the South Platte River basin. Metals lead in production values with coal a close second. The aggregate value of gold, silver, copper, lead, and zinc mined within the basin in 1935 was $5,124,200. The gold produced in 1940 was valued at $4,203,300 - approximately 90% of that year's total, with silver and lead second and third, respectively. Production of gold reached a peak in 1900 after which it declined until 1929. Since then it has increased steadily but not greatly. Coal is the principal non-metal produced within the basin. The output of sub-bituminous coal in 1935 was 2,051,435 tons. Other non-metals produced are gypsum, clay, lime, building stone, sand, gravel, mica and cement.

Petroleum production within the basin reached a peak of 1,230,100 barrels with an estimated value of $2,900,000 in 1926. The output has diminished greatly since that time however, the production in 1940 being only 161,000 barrels. With the installation of a pipeline from the Lance Creek field in Wyoming to the vicinity of Denver in 1938, petroleum refining has become an important industry in the basin. Natural gas occurs in the basin near Ft. Collins and Berthoud, Colorado. The only production at present is from the Berthoud field and is used for the manufacture of gasoline. There has been increased activity in the petroleum field during the past few years, particularly in location and prospecting operations.

Lumber produced in 1940 in the South Platte River basin was valued at $46,500. The products consisted chiefly of rough timbers and telegraph and telephone poles.

Transportation facilities in the Basin: -

Railroads. The South Platte River basin is served by five major railroads, the Union Pacific, the Chicago, Burlington and Quincy, the Denver and Rio Grande Western, the Colorado and Southern, and the Atchison, Topeka, and Santa Fe. The main line mileage within the basin is 1,471 miles, of which 366 miles are double tracked. In addition the Great Western Sugar Company operates a standard gage rail system, 85 miles in length, during the beet harvesting season to facilitate deliveries to its factories. Completion of the Moffat Tunnel in 1928 shortened the distance to the Pacific Coast by 176 miles and greatly improved transportation facilities serving Denver and the central and southern parts of the basin.

Highways. The basin area is served by an extensive highway system including transcontinental U. S. Highways, state highways, and secondary "farm to market" roads. The total mileage of all types, excluding city streets, is 27,744 miles of which about 3,000 miles are included in the federal and state highway systems.

Airways. Denver is one of the key administration centers for airways and serves as an airways communication and traffic control center for the general western territory. The United, Western, Continental, Braniff, Challenger, and Monarch Airlines provide passenger, freight and mail service, both transcontinental and local.

Waterways. There are no waterways suitable for commercial navigation within the South Platte River basin.

Land Ownership in the Basin: -

There are approximately 4,900 square miles of public land within the South Platte River basin, including national forests and parks, military reservations, public domain, state lands, and municipal parks. The national forests were created primarily for the production of timber and for the protection of watersheds. The Pike, Arapahoe, Roosevelt, Medicine Bow, and Cochetopa National Forests are all or partly included in the basin; a total area of about 2,700 square miles. About 260 square miles of the Rocky Mountain National Park area are included within the basin. Government reservations are scattered throughout the basin, including Lowry Field, Buckley Field, Fitzsimons General Hospital, and the Rocky Mountain Arsenal near Denver, Fort Francis E. Warren near Cheyenne, and Sioux Ordnance Depot near Sidney, Nebraska. The total area of these military reservations is about 180 square miles.

Table 16 presents a summary of the land ownerships within the basin area and the percentage of the basin in each classification.

TABLE 16

Land Ownership in South Platte River Basin.

Ownership	Area sq.mi.	Percent of basin
Federal Government:		
National forests and parks	3,031	13
Military reservations	181	1
Public domain	320	1
Sub-total	3,535	15
State lands	1,377	6
Municipal mountain parks	35	--
Private	17,423	73
Unclassified (water area and miscellaneous)	1,660	6
Total	24,030	100

Basin Water Supply and Water Usage: -

The basin water supply consists of surface, ground, and transmountain diversion water. The present annual supply from all sources is about 2,800,000 acre feet. Projects now under construction, or in the planning stage, will greatly increase the transmountain diversion supply and will furnish water for hydro-electric power, as well as supplement present irrigation supplies. Surface water supplies have been greatly over-appropriated for irrigation usage so that irrigation by pumping from ground water sources has greatly increased in recent years. This is especially true in the lower reaches of the main stem where ground water is available at depths of from 40 to 200 feet. In 1939, about 240,000 acre feet of water were pumped for irrigation purposes.

Irrigation. The major water use in the basin is for irrigation. Soils of the piedmont areas are quite fertile and are suitable for cultivation and, when supplied with adequate water, produce excellent yields. The use of surface waters for irrigation purposes depletes the natural stream flow in proportion to the amount of water appropriated for this purpose. The rights to water usage in the basin, as in most arid or semi-arid states, is based upon the doctrine of appropriation, under which, first in time is first in right - and beneficial use is the basis of measure and limit of

TABLE 17

SUMMARY OF WATER COMMISSIONER'S CROP REPORT FOR THE IRRIGATION SEASON OF 1944 IRRIGATION DIVISION NO. 1, COLORADO, EXCLUDING DISTRICTS IN THE NORTH PLATTE AND KANSAS RIVER BASINS

Dist. No.	First Day Water Used From Natural Stream	Last Day Water Used From Natural Stream	No. Acre Feet Used For Season	Total No. Acres that can be Irrigated	C R O P S **			Total Irrigated
					Alfalfa	Natural Grasses	Cereals	
1	5- 8-44	10-31-44	306,757	163,912	35,342	14,505	28,797	151,628
2	5- 1-44	10-31-44	374,259	226,700	39,462	10,628	80,277	219,670
3	5- 7-44	11- 6-44	332,900	380,000	64,616	5,007	72,859	264,160
4	5- 7-44	10-31-44	160,831	167,000	38,350	305	72,690	141,210
5	5-16-44	10-31-44	113,919	112,235	34,830	8,865	49,215	111,635
6	5- 1-44	10-29-44	102,316	*195,335	28,492	61,125	45,605	* 172,414
7	5- 1-44	10-31-44	133,624	117,180	13,505	1,230	52,314	95,121
8	4- 1-44	10-31-44	126,884	120,000	9,826	958	6,141	23,635
9	3- 1-44	10-31-44	33,642	16,349	4,818	1,653	5,069	14,064
23	4-27-44	10-31-44	E.120,000	50,000	.....	40,000	.....	40,000
64	4- 9-44	11-31-44	282,216	195,184	37,665	29,926	41,789	171,884
TOTALS			2,087,348	1,743,895	306,906	174,202	454,756	1,405,421

E - Estimated

* Acreage reported too high since 1922. Land cruise of 1930 shows irrigated area to be 72,142 acres.

** Additional crop figures shown on Continuation Sheet of this Table.

TABLE 17 (Continuation Sheet)

Dist. No.	CROPS								
	Orchards	Market Gardens	Potatoes	Sugar Beets	Beans	Peas	Cabbage	Corn	Other
1	152	371	2,069	13,471	20,925	....	17	25,714	10,265
2	340	12,059	11,777	27,668	23,460	760	2,192	......	11,047
3	1,567	3,915	29,079	35,308	11,554	570	803	......	38,882
4	2,020	645	7,802	9,020	3,260	2,210	421	2,570	1,917
5	90	670	200	16,525	....	.....	540	.....	700
6	655	2,562	335	4,320	1,090	465	139	18,438	9,188
7	1,632	10,803	156	1,540	867	335	1,197	6,585	4,957
8	31	2,211	10	162	10	.....	.....	......	4,286
9	89	350	....	175	35	.....	100	1,340	435
23	.....	.....	....	.....	.....	.....	.....	......	.....
64	125	983	3,602	16,699	5,259	0	30	29,885	5,921
TOTALS	6,701	34,569	55,030	124,888	66,460	4,340	5,439	84,532	87,598

the right. The water in surface streams is owned by the public, and its use is administered by the public, through the State Engineers. The right to use waters from streams is based upon priority of appropriation. Appropriations are adjudicated in amount from time to time, so as to insure proper division of the supply from any given source among all users. The present stream flows in the basin are greatly over-appropriated so that the amount of irrigated lands has remained static for the past 50 years or more, as they are limited by the amount of water available from the streams for irrigation purposes - all of which had been appropriated before 1900.

Table 17 shows the irrigated acreage in the South Platte Basin in Colorado for the season 1944, as taken from the biennial report of the Colorado State Engineer for 1943-1944. Water districts in the division outside of the South Platte basin were omitted from the table. Figure 2 shows the area covered by Irrigation Division No. 1 which includes all of the South Platte River Basin in Colorado. Figures 3, 4, and 5, copied from diagrams prepared by the Colorado State Engineer, show diversions along the main stem of the South Platte River. Water storage in the basin available for irrigation and other purposes for the year 1944 is shown in Table 18. Peak storage is available during the summer months due to the heavy run-off from April to June of streams in the area. Irrigation usage is reflected in decreased storage from July to October.

Trans-mountain Diversions. It is anticipated that completion of the Colorado-Big Thompson transmountain diversion project by the Bureau of Reclamation will make available some 300,000 additional acre feet of water annually for irrigation purposes in the basin below Platteville, principally on the Cache la Poudre, Thompson, and St. Vrain tributary drainage systems (See Exhibit I). Should the Blue-South Platte Project, now under consideration by the Bureau of Reclamation, be approved, another 430,000 acre feet of transmountain diversion water will be available for use in the area from the North Fork to Ft. Lupton and eastward to Kiowa Creek (see Exhibit II). This project will furnish 49,000 acre feet of supplementary water for Denver municipal use.

Table 19, taken from the Biennial Report of the Colorado State Engineer (1943-1944), shows the water available to the South Platte River basin from transmountain diversions for the year 1944. In that year, a total of about 61,000 acre-feet was available from these sources, including some 16,000 acre feet utilized by the Denver water supply.

Surface Water Supplies. In 1940, approximately 418,000 persons in the basin were served with water supplies from surface sources. Table 20 lists all communities in the South Platte Basin which are served by surface water supplies. All other communities use ground water sources. Approximately four-fifths of these consumers were served by the Denver Supply which is the most extensive in the Basin and which serves practically the entire metropolitan Denver Area. In 1947, the Denver Water Board Annual Report estimated the total population served by this system as about 440,000. On this basis, present population in the basin served

TABLE 18

The following is a statement of Water in Storage in South Platte River Basin in Colorado from January 1 to December 1, 1944.

Values in Acre Feet

Dist. No.	Jan.	Feb.	Mar.	Apr.	May	June
1	63,165	82,172	102,309	116,366	131,313	134,111
2	21,946	29,072	41,089	51,375	81,227	92,483
3	65,607	70,878	74,916	81,142	102,981	129,104
4	37,852	37,795	39,644	40,125	65,495	89,753
5	9,360	10,000	10,902	11,937	23,280	31,299
6	17,149	17,913	17,305	17,118	23,531	35,530
7	8,122	12,102	12,778	4,402	5,692	13,879
8	15,247	17,565	16,970	16,451	17,799	17,229
9	2,811	3,199	4,022	4,372	7,554	8,468
23	166,281	162,648	163,031	164,678	178,380	185,286
64	59,549	74,291	83,321	102,284	122,781	117,517
TOTALS.....	467,089	517,635	566,287	610,250	760,033	854,659
City of Denver...	187,389	184,282	183,418	183,255	196,445	209,189
Bal. for Irrig. .	279,700	333,353	382,869	426,995	563,588	645,470

Dist. No.	July	August	Sept.	Oct.	Nov.	Dec.
1	112,045	73,523	19,425	2,590	2,489	30,305
2	82,402	64,915	30,531	15,296	13,095	18,844
3	122,912	101,894	43,600	29,155	29,792	33,300
4	85,604	74,062	48,078	37,717	34,723	34,767
5	31,316	21,082	11,903	6,344	6,221	5,954
6	34,222	30,128	22,130	17,394	15,841	14,590
7	13,126	12,908	9,575	8,221	7,722	7,076
8	16,100	16,282	14,253	12,100	14,178	14,842
9	7,232	5,381	2,857	2,065	1,721	1,700
23	185,000	182,862	173,312	168,307	162,491	160,302
64	95,807	80,546	37,075	14,757	27,145	39,109
TOTALS....	785,766	663,583	412,739	314,046	315,418	360,789
City of Denver...	206,716	207,723	195,363	187,062	183,160	180,653
Bal. for Irrig. .	579,050	455,860	217,376	126,984	132,258	180,136

From Colorado State Engineer Report 1943-1944.

TABLE 19

TRANS-MOUNTAIN DIVERSIONS TO SOUTH PLATTE RIVER BASIN
- STATE OF COLORADO -

Irrigation Division No. 1
for 1944

Name of Diversion	From Dist.	To Dist.	Source of Supply	First Day	Last Day	Acre Feet
Deadman Ditch	48	3	Laramie River		....	0
Laramie-Poudre Tunnel	48	3	Laramie River	5-21	7- 3	9,082
Skyline Ditch	48	3	Laramie River	5-21	7-18	10,576
Lost Lake Ditch	48	3	Laramie River	5-25	6-17	217
Columbine Ditch	48	3	Laramie River		....	0
Bob Creek Ditch	48	3	Laramie River		....	0
Sand Creek Ditch	48	3	Sand Creek	5-26	6-10	1,705
Michigan Ditch	47	3	North Platte River	6-15	8- 5	1,797
Cameron Pass Ditch	47	3	North Platte River	6-19	7-15	186
Grand River Ditch	51	3	Colorado River	5-30	9- 2	16,629
Moffat Tunnel	51	6-7	Colorado River	5-31	11- 7	16,196
Williams Fork Tunnel	51	7	Colorado River	7- 4	9-17	3,941
Berthoud Pass Ditch	51	7	Colorado River	6-20	8- 5	430
Eureka Ditch	51	4	Colorado River	6-25	9-10	95
			TOTAL			60,854

Irrigation Division No. 1 comprises South Platte River drainage basin, except for Districts 47 and 48 in North Platte River Basin and District 65 in Kansas River Basin.

From Colorado State Engineer Report 1943 - 1944.

TABLE 20

SURFACE WATER SUPPLIES IN SOUTH PLATTE RIVER BASIN

Community	1940 Population	Description of Supply
Littleton, Colo.	2,244	South Platte River - infiltration gallery and two shallow wells. Only treatment chlorination.
Denver	322,412	Two sources of supply used: (a) South Platte River - approximately 70% of supply from this source together with Bear Creek and Cherry Creek. Intake at Platte Canyon. Bear Creek intake at Morrison. Cherry Creek infiltration galleries at Sullivan. Drainage area, 3,270 sq.mi. above intakes. Three impoundments are located on Platte headwaters (193,400 A.F.). Treatment by 2 rapid sand filtration (85.0 M.G.D.) and 1 slow sand filtration (30.0 M.G.D.) plants and by chlorination. (b) Fraser River - approximately 30% of supply from this source. Diversion to east slope of divide through Moffat Tunnel to S. Boulder Creek to Ralston Creek Reservoir (10,700 A.F.). Rapid sand filtration and chlorination (56.0 M.G.D.).
Fairplay	739	Beaver Creek and spring. Infiltration gallery from Beaver Creek. Spring uncovered. Hypochlorinator for emergency use only (0.25 M.G.D.).
Evergreen	350	Water taken from Bear Creek below Evergreen Dam. Treated by pressure filters. Hypochlorinator. (0.20 M.G.D.).
Morrison	216	Direct from Bear Creek. Use zeolite filters - chlorinated. (0.25 M.G.D.).
Palmer Lake	269	Impounded from (1) Thompson Creek and (2) Ice Cave Canyon. No treatment. (0.25 M.G.D.)
Georgetown	391	Diverted from Leavenworth Creek to concrete reservoir at edge of town. Flows through two power company reservoirs. No treatment.
Idaho Springs	2,112	Diverted from Chicago Creek and Devil's Canyon. Soda Creek used as emergency. Chicago Creek main source. Diverted to filter basin and chlorinated. (0.25 M.G.D.)

TABLE 20 (Continued)

Community	1940 Population	Description of Supply
Golden	3,175	Long Lake Reservoir (1400 A.F.) Beaver Creek used as emergency. Supply chlorinated. (0.50 M.G.D.).
Nederland	384	Boulder Creek. No treatment. (0.25 M.G.D.).
Boulder	12,958	Impounded supply (3500 A.F.) Protected watershed, City owned (6,000 acres) Chlorinated (6.0 M.G.D.)
Louisville	2,023	South Boulder Creek to Marshall Lake to Louisville Reservoir (160 A.F.) Rapid sand filtration and chlorination (1.0 M.G.D.)
Lafayette	2,053	South Boulder Creek to rapid sand filtration and chlorination. (0.5 M.G.D.).
Erie	1,019	South Boulder Creek to South Boulder Canyon, irrigation ditch to Erie Reservoir (120 A.F.). Rapid sand filtration and chlorination. (0.5 M.G.D.).
Lyons	654	North St. Vrain Creek - inadequate supply. Treatment by pressure filters. (0.25 M.G.D.)
Longmont	7,406	North and South St. Vrain Creeks. Treatment by 5.0 M.G.D. rapid sand filtration plant and chlorination. Inadequate capacity.
Estes Park	994	Two sources of water used: (a) Glacier Creek - diversion to sand trap and chlorinator. About 1.0 M.G.D. (b) Black Canyon - diversion to small settling basin. No treatment. About 1.0 M.G.D.
Loveland	6,145	Thompson River below Drake. Rapid sand filtration. Chlorination. (6.0 M.G.D.)
Berthoud	811	Thompson River to Handy Irrigation Ditch to settling basins (2.0 M.G.) Rapid sand filtration and chlorination. Storage in Turner Lake for winter use.

TABLE 20 (Continued)

Community	1940 Population	Description of Supply
Johnstown	961	Thompson River to Home Supply Ditch to two reservoirs (total 275 A.F.). Coagulation, sedimentation, and chlorination. (1.5 M.G.D.)
Ft. Collins	12,251	Cache la Poudre River. Rapid sand filtration and chlorination. Patrolled and protected watershed. (9.0 M.G.D.)
Greeley	15,995	Cache la Poudre River 3 miles below North Fork junction. Patrolled watershed. Impoundment at Milton Seamen Dam on North Fork 3/4 mile above junction with main stream. 3.72 acres of slow sand filters and chlorination. (9.0 M.G.D.).
Cheyenne,Wyo.	22,474	3 impoundments on Upper Crow Creek. (10,700 Acre Feet), and 14 wells (4.5 M.G.D.). Surface supply treated by aeration, rapid sand filtration and chlorination. (Cl_2 - NH_3). (12.0 M.G.D.).

TABLE 21

CONSUMPTION OF FILTERED WATER

Year	Daily Average G.P.D.	Estimated Population	Gallons per Capita
1918	49,109,837	268,000	183
1919	53,803,655	270,000	199
1920	53,146,745	272,000	195
1921	52,733,472	276,000	191
1922	55,904,248	285,000	196
*1923	53,759,935	295,000	182
1924	60,344,769	306,000	197
*1925	55,203,076	313,000	176
1926	57,812,406	316,000	183
1927	60,932,356	320,000	190
1928	65,442,432	323,000	203
*1929	61,635,123	325,000	190
*1930	67,831,863	326,000	208
1931	67,401,205	329,000	205
*1932	62,886,311	331,000	190
**1933	58,687,506	331,000	177
**1934	61,694,109	338,000	183
**1935	51,867,918	340,000	153
*1936	57,630,629	345,000	167
1937	61,286,301	350,000	175
1938	56,519,452	354,000	160
1939	69,947,370	360,000	194
1940	64,034,645	370,000	173
1941	60,327,096	380,000	159
1942	70,788,521	405,000	175
1943	77,840,685	407,000	191
1944	76,710,000	409,000	188
1945	71,035,342	414,000	172
1946	79,969,315	423,000	189
1947	80,397,000	440,000	183

* Irrigation on alternate days only.
** Special irrigation restrictions.

Taken from 1947 Report of the Denver Board of Water Commissioners.

by surface supplies would exceed 550,000. About 30% of the Denver supply is obtained by transmountain diversion via the Moffat Tunnel. The remainder is supplied from east slope sources, principally from the South Platte River with about 8% from Cherry and Bear Creeks. Figure 6 shows the main features of the Denver water supply sources. Table 21 shows the water consumption for Denver from 1918 to 1947.

Varying amounts of water are used throughout the basin for manufacturing and railroad use. For the most part, this water is obtained from the various municipal supplies. However, sugar factories or canning plants in rural areas use other available surface or ground water supplies.

Recreational Use of Reservoirs. Attention is directed to the fact that some of the reservoirs on the Colorado-Big Thompson Project are located adjacent to popular summer resort areas. Of particular interest from this standpoint are Granby, Shadow Mountain, Mary's Lake, Estes, and possibly Horsetooth reservoirs. The first four reservoirs are located immediately adjacent to Rocky Mountain Park, and Mary's Lake and Estes reservoirs are practically in the town of Estes Park. Heavy usage of these reservoirs for recreational purposes will necessitate measures being taken both to control the pollution of the reservoirs and to safeguard those using the areas. The former measures require that the discharge of raw sewage and other wastes be strictly controlled and the latter require that adequate sanitation facilities and safe water supplies be furnished, and that adequate safety regulations be enforced. The usage of operating reservoirs, such as Horsetooth, for recreational purposes may be limited because of the wide fluctuations in water levels. The possible effects of recreational uses of reservoirs as contributing factors in the sanitary quality of water used for irrigation or other purposes are problematical and are not given further consideration in this interim report. Further consideration will be given to this matter in the final report on this survey.

PRESENTATION OF DATA

Sources of Pollution: -

Domestic Sewage. Approximately 540,000 persons (based upon 1940 population) were served by sewer systems which were being discharged into the South Platte River system. Of this number, approximately 29,000 or slightly over 5% were discharging untreated wastes. The remaining sewered population was connected to some type of treatment. Only about 44,000 persons, or about 8%, were connected to sewage treatment plants providing secondary treatment.

Approximately 69% of the 1940 sewered population in the South Platte basin is located in Denver. In addition, Denver sewers receive packing house and other industrial wastes which increase the equivalent population somewhat. Based upon average 5-day BOD of 215 ppm for the raw sewage, and an average daily flow of 58.8 M.G.D., as indicated by 1948 data shown in Table 22, the population equivalent of the raw sewage for Denver is presently about 630,000. This is reduced to about 380,000 or by about 40% by primary treatment and chlorination before discharge into the river.

TABLE 22

Monthly Average Flow and B.O.D. of Denver Sewage 1948

Month	Flow MGD	5-day 20°C B.O.D. Raw Sewage	5-day 20°C B.O.D. Treated Sewage
January	56.4	227	141
February	57.7	194	133
March	57.6	230	114
April	57.7	217	138
May	61.5	319	185
June	64.9	207	117
July	65.7	188	108
August	65.2	177	100
September	56.2	174	119
October	54.9	201	123
November	55.8	206	124
December	52.6	242	159
Total	706.2	2582	1561
Average	58.8	215	130

Note: These figures are obtained from records of the Colorado State Board of Health.

TABLE 23

ANNUAL RETURN FLOW TO SOUTH PLATTE RIVER THROUGH DENVER SANITARY AND STORM SEWERS

1927 - 1947

Year	City Consumption Filtered Water Ac. Ft.	Return thru Sanitary Sewers Ac. Ft.	% Return Sanitary Sewers	Return thru Storm Sewers Ac. Ft.	% Return Storm Sewers
1927	68,222	52,595	77.1	No Record	No Record
1928	73,506	53,181	72.3	No Record	No Record
1929	69,040	53,143	77.0	No Record	No Record
1930	76,201	51,103	67.0	No Record	No Record
1931	75,772	50,614	66.8	4,690	6.2
1932	70,890	48,464	68.4	4,972	7.0
1933	65,976	46,276	70.1	6,368	9.6
1934	69,356	42,671	61.5	4,018	5.8
1935	58,310	41,648	71.4	3,588	6.2
1936	64,966	46,593	71.7	3,794	5.8
1937	68,898	47,962	69.6	4,992	7.2
1938	63,539	46,486	73.2	6,748	10.6
1939	78,635	46,964	59.7	7,464	9.5
1940	72,185	51,535	71.4	6,318	8.8
1941	67,820	55,899	82.4	7,378	10.9
1942	79,580	60,523	76.1	6,372	8.0
1943	87,508	59,238	67.7	6,280	7.2
1944	86,474	60,790	70.3	6,472	7.5
1945	79,858	59,669	74.7	6,368	8.0
1946	89,902	62,582	69.6	6,228	6.9
1947	90,382	68,788	76.1	6,194	6.9

Taken from 1947 Report of the Denver Board of Water Commissioners.

The city of Denver presents the greatest single source of pollution in the South Platte Basin. Table 23 shows the percentage return of Denver water consumption to South Platte River as sewage.

Figure 7 shows a diagrammatic map of the basin and indicates the location and approximate magnitude of various sources of municipal sewage pollution. Except in the case of Denver, the amount of pollution indicated does NOT include the population equivalent of industrial wastes. The pollution load indicated for Denver in Figure 7 was computed from 1948 flow and B.O.D. data obtained from State Health Department records and, therefore, includes the population equivalent (B.O.D. basis) of industrial wastes discharged into the Denver city sewers.

Problems of a similar character, but of lesser magnitude, are found below Golden, Boulder, Greeley, Loveland, Longmont, and Ft. Collins. In all cases, water is diverted immediately below these communities for irrigation use. In this connection, reference is made to Figure 7 which shows graphically the laboratory results on samples taken from the Burlington-O'Brian ditch below Denver.

Industrial Wastes. Data on industrial wastes in the basin are fragmentary and incomplete at this time. A survey of the City and County of Denver was carried out by the City Health Department in September and October 1948. The report prepared by the City Bureau of Health and Hospitals (see Appendix "C") concludes that:

"The amount of pollution contributed to the South Platte River and Cherry Creek by industries in the City of Denver is relatively low. The greater part of wastes returned or disposed of in the river is cooling water and the effect is one of temperature rise rather than outright pollution. The most serious types of pollutants found in the river in Denver are oil and grease from railroad roundhouses. Packing plants, for the most part, discharge their waste material into the city sewers and are, therefore, not responsible for any subsequent pollution. The single plant which is now discharging paunch manure into the river will be assisted in corrective measures in the near future.

"Only two cases of chemical pollution were found, and they are not considered to be of a very serious nature. The lime discharged by an acetylene producing plant creates a problem of deposition, while the discharge from the other plant actually contains very small amounts of acid.

"The remaining pollution material is due to the drain from the city operated dump and indiscriminate use of drainage ditches and the river as dumps by individuals. The degree of pollution is difficult to estimate, but must be considered in the overall picture of the problem."

These conclusions are supported by the laboratory data (Table 24) which shows only a moderate increase in the biochemical oxygen demand and in the coliform content of the river from the southern limits, Station 314.4, to above the Denver sewage disposal plant outfall, Station 300.0, while the dissolved oxygen content remains at 90% or more saturation level in the same stretch.

The largest single industry outside of Denver contributing wastes to the streams is probably the beet sugar industry with 13 plants scattered throughout the basin. These plants produce nearly 1/4 of the total beet sugar production of the United States. Plants are located at Eaton, Greeley, Windsor, Ft. Collins, Loveland, Longmont, Brighton, Ft. Lupton, Johnstown, Ovid, Sterling, Brush, and Ft. Morgan. Seven of these plants use the Steffans process and one, Johnstown, handles only molasses. Lagooning of wastes is practiced to some extent. Table 26 shows results of BOD analysis of wastes from Windsor and Ft. Collins plants in November 1948. Accurate flow data were not obtainable at the time. Operation of these plants is reflected in stream samples collected in November and December 1948, especially on the Cache la Poudre and Thompson Rivers and in the South Platte below these streams. A summary of a literature survey on beet sugar processing wastes is presented in Appendix "D".

Accurate data on all sources of pollution in the basin will be obtained during the remaining course of this survey and will be available for presentation in the final report.

Laboratory Data: -

Table 24 summarizes the results of the laboratory data covering operations to March 1, 1949. The data are presented as monthly summaries for all stations sampled during this period. The averages of the results are shown graphically in Figures ~~7~~, 8, 9, and 10. ~~Figure 7 shows main stem results only~~. Figure 8 shows the dissolved oxygen results; Figure 9, the 5-day BOD results; and, Figure 10, the coliform results expressed as median MPN's per 100 ml for the entire basin area covered to date. In addition to the samples from the streams, samples were taken along the Burlington-O'Brian Ditch system supplying water for irrigation to Barr Lake reservoir northeast of Denver. This ditch system receives much of the effluent from the Denver treatment plant during low flow conditions of the river.

Inclement weather conditions interfered with stream sampling during most of January and the first part of February 1949. Blizzard conditions and low temperatures disrupted routine operations.

Hydrometric Data: -

No hydrometric data are available for inclusion in this report. However, complete data will be available for the final report.

DISCUSSION

General: -

The data available at this time are not sufficient to provide answers to the objectives of this survey. Considerable information is required on sources of pollution, more especially on the extent, location, and types of industrial wastes. Laboratory data are confined largely to the

TABLE 24

SUMMARY OF LABORATORY RESULTS

Monthly Averages for All Sampling Stations

Sampling point mileage	Month /Year	No. of samples	Discharge sec.-ft.	Averages					Median coliform M.P.N. per 100 ml.	Average chemical determinations			
				Temp. °C.	Turbidity, ppm.	Dissolved Oxygen		5-Day BOD. ppm.		pH	Alkalinity, ppm.	Hardness, ppm.	Copper ppm
						ppm.	% Sat.						
South Platte River													
SP 314.4	12/48	1	No data available at this time	1.0	--	11.16	95.0	1.8	460	7.14	--	--	--
	1/49	5		0.9	--	11.09	95.0	1.2	430	7.61	--	--	.085
	2/49	6		2.0	--	11.09	99.2	1.5	1,665	7.82	148	182	.060
SP 309.3	12/48	1		4.0	--	11.50	106.0	1.2	46,000	7.24	--	--	--
	1/49	6		2.9	--	11.06	98.0	2.4	23,000	7.71	209	227	.108
	2/49	6		2.7	--	11.28	99.7	1.9	9,300	7.81	192	205	.070
SP 302.3	12/48	1		7.0	--	9.16	91.0	5.0	7,500	7.26	--	--	--
	1/49	5		6.8	--	9.42	93.0	5.0	9,300	7.7	202	227	.120
	2/49	6		9.0	--	9.42	97.8	3.7	33,500	7.93	206	228	.070
SP 300.0	12/48	1		10.0	--	9.38	100.0	7.6	2,400	7.34	--	--	.140
	1/49	6		5.8	--	9.56	92.0	6.7	18,000	7.75	--	---	.140
	2/49	6		7.7	--	9.48	94.0	6.0	19,000	7.82	214	--	.090
SP 299 R	12/48	1		11.0	--	8.26	90.0	58.5	43,000	7.36	--	--	--
	1/49	6		7.4	--	7.50	75.0	94.0	445,000	7.87	215	250	.203
	2/49	6		8.1	--	8.10	83.0	61.4	230,000	8.00	222	--	.140
SP 299 L	12/48	1		12.0	--	4.08	45.0	282.5	91	7.30	--	--	--
	1/49	6		8.4	--	4.58	47.0	136.0	680	7.56	214	205	.217
	2/49	6		8.6	--	6.61	67.6	78.8	33,000	7.67	212	--	.120

TABLE 24 (Continued)

Sampling point mileage	Month /Year	No. of samples	Discharge sec.-ft.	Averages					Median coliform M.P.N. per 100 ml.	Average chemical determinations			
				Temp. °C.	Turbidity, ppm.	Dissolved Oxygen		5-Day BOD. ppm.		pH	Alkalinity, ppm.	Hardness, ppm.	Copper ppm
						ppm.	% Sat.						
South Platte River (Continued)													
SP 295.5	1/49	6	No data available at this time	4.3	--	7.78	72.0	25.0	33,500	7.61	275	273	.130
	2/49	5		5.6	--	6.77	64.6	26.2	46,000	7.50	278	--	.080
SP 272.2	12/48	4		0.2	--	9.91	82.0	6.0	23,500	7.92	--	--	--
	1/49	6		0.0	--	9.62	79.0	2.7	9,300	7.8	286	202	.036
	2/49	9		1.3	79	8.36	70.4	12.1	24,000	7.7	269	198	.030
SP 247.8	10&11/48	6		7.7	--	6.04	59.0	56.3	230,000	8.04	--	--	--
	12/48	7		0.7	--	10.03	83.0	9.0	23,000	8.09	--	--	--
	1/49	7		0.0	--	8.58	70.0	2.2	24,000	7.9	283	147	.037
	2/49	9		1.8	82	8.86	75.6	5.9	75,000	7.78	258	175	.030
SP 234.5	10&11/48	8		8.0	--	6.91	73.0	32.4	93,000	8.0	--	--	--
	12/48	7		0.7	--	9.70	79.8	15.7	23,000	8.04	--	--	--
	1/49	6		0.0	--	11.0	90.0	2.3	8,400	7.9	288	125	.036
	2/49	9		1.8	104	10.76	91.5	6.2	9,300	7.88	269	147	.040
SP 226.9	10&11/48	7		7.6	--	5.67	56.0	31.8	430,000	7.78	--	--	--
	12/48	7		0.7	--	9.56	78.7	11.2	75,000	8.06	--	--	--
	1/49	6		0.0	--	9.86	80.0	3.3	84,000	7.85	300	116	.042
	2/49	9		1.5	82	9.55	80.7	5.5	43,000	7.8	283	134	.037

TABLE 24 (Continued)

Sampling point mileage	Month /Year	No. of samples	Discharge sec.-ft.	Averages					Median coliform M.P.N. per 100 ml.	Average chemical determinations			
				Temp. °C.	Turbidity, ppm.	Dissolved Oxygen ppm.	Dissolved Oxygen % Sat.	5-day BOD. ppm.		pH	Alkalinity, ppm.	Hardness, ppm.	Copper ppm
						Bear Creek							
Be 0.75	12/48	1		2.0	--	11.14	97.0	4.0	93	7.3	--	--	--
	2/49	2		4.5	--	11.33	107.0	2.7	2,350	7.85	--	--	--
						Burlington Ditch							
14	12/48	4	No data available at this time	1.6	--	0.40	3.2	88.1	395,000	7.6	--	--	--
	2/49	2		4.0	--	0.15	1.3	83.0	3,050,000	--	--	--	.140
10.5	1/49	3		4.5	--	1.53	14.6	63.0	150,000	7.40	--	--	.160
	2/49	2		4.5	--	0.38	3.4	88.5	5,715,000	7.37	--	--	.100
8.7	1/49	3		5.0	--	2.88	27.0	45.0	93,000	7.42	--	--	.200
	2/49	2		4.5	--	2.94	27.0	81.5	2,321,500	7.44	--	--	.120
4.8	1/49	3		5.2	--	4.33	41.0	39.3	230,000	7.47	--	--	.180
	2/49	2		5.0	--	3.05	28.5	47.5	2,321,500	7.45	--	--	.140
3.0	1/49	3		5.2	--	5.32	50.0	49.0	930,000	7.43	--	--	.220
	2/49	2		5.5	--	4.67	45.5	48.0	1,310,000	7.47	--	--	.140
0.5	12/48	1		11.0	--	4.74	52.0	174.0	93,000	7.34	--	--	--
	1/49	9		6.2	--	5.62	54.0	80.0	9,300	7.57	208	227	.160
	2/49	9		8.0	--	6.03	61.2	67.9	12,500	7.58	--	--	.130

TABLE 24 (Continued)

Sampling point mileage	Month /Year	No. of samples	Discharge sec.-ft.	Averages					Median coliform M.P.N. per 100 ml.	Average chemical determinations			
				Temp. °C.	Turbidity, ppm.	Dissolved Oxygen ppm.	Dissolved Oxygen % Sat.	5-day BOD. ppm.		pH	Alkalinity, ppm.	Hardness, ppm.	Copper ppm
Clear Creek													
Cl 38.5	12/48	1	No data available at this time	0.0	--	10.66	94.0	1.9	2,400	6.90	--	--	--
	2/49	1		3.0	--	10.94	105.0	0.9	230	7.45	--	--	--
Cl 33.2	12/48	1		0.0	--	10.58	94.0	1.8	4,600	7.30	--	--	.120
	2/49	1		4.0	--	11.06	109.0	0.8	4,300	7.20	--	--	--
Cl 18.0	12/48	1		1.7	--	11.72	104.0	1.8	430	7.35	--	--	.120
	2/49	1		4.0	--	11.18	110.0	1.1	4,300	7.20	--	--	---
Cl 17.5	12/48	1		2.8	--	10.62	97.0	14.0	46,000	7.61	--	--	.110
	1/49	3		1.5	--	10.71	94.0	20.2	240,000	7.42	--	--	.100
	2/49	4		2.5	--	10.24	92.7	33.0	680,000	7.42	--	--	.040
(Wanamaker	12/48	1		5.0	3	10.64	97.0	61.0	460,000	7.30	--	--	.110
(Ditch	1/49	3		1.2	--	10.59	93.0	18.7	930,000	7.27	--	--	.140
(Cl 17.5	2/49	4		2.7	--	10.71	97.2	38.7	2,400,000	7.44	--	--	.100
Cl 0.8	2/49	1		7.0	--	11.62	115.0	4.0	23,600	7.70	--	--	--
St. Vrain River (SV) - Boulder Creek (SV-Bo) - Coal Creek-mouth (SV-Bo-Co)													
SV 29.0	1/49	2		0.0	--	11.24	94.0	3.5	2,300	7.80	234	283	.030
	2/49	7		2.5	15	10.47	93.0	3.0	910	7.70	226	301	.010
SV 26.0	1/49	1		0.0	--	--	--	28.4	230,000	7.70	338	255	.040
	2/49	7		4.4	26	8.28	77.0	13.3	430,000	7.70	340	353	.020

TABLE 24 (Continued)

Sampling point mileage	Month /Year	No. of samples	Discharge sec.-ft.	Averages					Median coliform M.P.N. per 100 ml.	Average chemical determinations			
				Temp. °C.	Turbidity, ppm.	Dissolved Oxygen		5-day BOD. ppm.		pH	Alkalinity, ppm.	Hardness ppm.	Copper ppm
						ppm	% Sat.						
St. Vrain River (SV) - Boulder Creek (SV-Bo) - Coal Creek-mouth (SV-Bo-Co) (Continued)													
SV-Bo 26.0	1/49	2		-2.5	--	11.83	99.0	4.0	1,215	7.50	44	54	.060
	2/49	7		0.6	1	11.63	101.0	2.5	430	7.20	34	61	.040
SV-Bo 19.0	1/49	2		1.2	--	7.27	63.0	37.7	2,300,000	7.3	88	73	.090
	2/49	7		3.0	8	8.91	81.0	30.0	4,300,000	7.2	66	79	.050
SV-Bo-Co 0.3	2'49	2		3.7	20	7.65	70.0	4.1	17,500	7.5	164	235	--
Thompson River													
Loveland Waterworks T 32.3	2/49	5	No data available at this time	1.3	1	11.50	100.0	1.3	91	7.2	30	88	.040
T 26.3	1/49	3		0.2	--	10.73	90.0	5.5	4,300	7.7	219	283	.010
	2/49	6		1.0	3	10.86	92.0	1.5	4,300	7.7	200	469	.010
T 22.7	1/49	3		0.8	--	6.92	59.0	9.3	430,000	7.7	199	328	.040
	2/49	6		3.9	4	6.53	58.0	16.7	930,000	7.5	210	391	.030
T 19.3	1/49	2		1.0	--	6.85	58.0	7.4	190,000	7.6	233	237	.020
	2/49	6		2.3	7	6.49	57.0	11.4	161,500	7.5	225	396	.030
T 9.9	10&11/48	7		6.2	--	3.6	31.9	345.2	2,300,000	7.82	--	--	--
	12/48	7		0.0	--	5.39	44.0	227.0	15,000	7.84	--	--	--
	1/49	6		0.0	--	8.42	72.0	6.5	1,200	7.9	415	136	.037
	2/49	9		0.8	49	9.43	78.3	5.7	930	8.0	410	127	.035

TABLE 24 (Continued)

Sampling point mileage	Month /Year	No. of samples	Discharge sec.-ft.	Averages					Median coliform M.P.N. per 100 ml.	Average chemical determinations			
				Temp. °C.	Turbidity, ppm.	Dissolved Oxygen		5-day BOD. ppm.		pH	Alkalinity ppm.	Hardness ppm.	Copper ppm.
						ppm	% Sat.						
Thompson River (Continued)													
T 2.9	10&11/48	6		7.7	--	6.52	64.3	237.2	238,000	8.00	--	--	--
	12/48	7		1.1	--	7.39	61.8	116.0	430,000	8.07	--	--	--
	1/49	5		0.0	--	7.96	64.0	19.6	93,000	8.00	399	120	.045
	2/49	9		2.0	74	9.55	81.7	10.1	43,000	8.00	387	134	.030
Little Thompson River													
TLT 11.0	10&11/48	3	No data available at this time	2.7	--	9.48	82.0	2.0	9,300	7.95	--	--	--
	12/48	7		1.0	--	10.82	90.6	1.5	43,000	8.1	--	--	--
	1/49	6		0.0	--	10.14	83.0	1.0	19,000	8.0	405	131	.036
	2/49	9		1.5	71	10.37	87.7	1.4	23,000	8.08	390	110	.025
TLT 3.75	10&11/48	5		5.5	--	9.45	88.0	3.2	6,450	8.15	--	--	--
	12/48	7		0.1	--	10.74	88.0	1.7	4,300	8.2	--	--	--
	1/49	6		0.0	--	10.29	84.0	1.0	23,000	8.0	406	124	.036
	2/49	9		0.9	166	10.77	89.7	1.6	15,000	8.0	402	128	.030
TLT 2.0	10&11/48	5		6.5	--	8.61	82.8	46.9	230,000	8.2	--	--	--
	12/48	7		2.5	--	7.61	66.0	63.4	930,000	8.25	--	--	--
	1/49	6		0.1	--	7.17	59.0	53.7	840,000	8.3	490	125	.075
	2/49	9		4.6	155	8.38	76.6	33.0	430,000	8.1	397	116	.046
Cache La Poudre River													
CLP 38.8	1/49	4		0.4	--	8.42	71.0	2.1	670	7.6	214	228	.013
	2/49	6		1.8	34	8.92	78.0	2.0	2,300	7.6	231	288	.020
(Spring Cr.													
(Mouth	1/49	3		2.3	--	11.14	98.0	3.5	3,600	8.1	291	191	.010
(CLP 35.5	2/49	6		4.2	31	11.34	105.0	2.4	1,800	8.1	288	274	.020

TABLE 24 (Continued)

Sampling point mileage	Month /Year	No. of samples	Discharge sec.-ft.	Averages					Median coliform M.P.N. per 100 ml.	Average chemical determinations			
				Temp. °C.	Turbidity, ppm.	Dissolved Oxygen		5-day BOD. ppm.		pH	Alkalinity, ppm.	Hardness ppm.	Copper ppm.
						ppm	% Sat.						
Cache La Poudre River (Continued)													
CLP 35.0	1/49	4	No data available at this time	1.0	--	9.81	83.0	12.9	5,800	7.80	324	237	.010
	2/49	6		2.9	15	10.64	95.0	10.3	4,300	7.90	342	303	.010
CLP 21.8	1/49	3		0.0	--	8.64	70.0	1.6	4,300	7.80	337	150	.036
CLP 21.3	10&11/48	7		4.2	--	7.77	77.0	4.1	460,000	7.90	--	--	--
	12/48	4		0.7	--	10.06	83.5	2.6	23,500	8.00	--	--	--
	2/49	8		0.1	26	9.22	74.8	3.3	195,000	7.80	317	127	.037
(Windsor (Outfall	10&11/48	5		10.2	--	3.11	28.7	179.1	5,800	7.55	--	--	--
	12/48	3		3.0	--	3.72	32.6	17.1	360	7.70	--	--	--
	2/49	4		0.0	20	7.17	58.2	6.8	126,000	7.70	337	109	.050
(Sugar (Mill	10&11/48	5		10.0	--	.47	9.0	435.6	4,600,000	7.10	--	--	--
	12/48	2		3.5	--	0.0	0.0	170.0	68,000	6.70	--	--	--
	2/49	2		0.0	70	4.72	38.0	241.0	50	7.00	634	109	.110
CLP 20	10&11/48	6		9.0	--	.44	6.0	343.0	4,300,000	7.40	--	--	--
	12/48	5		1.2	--	7.77	64.8	20.2	43,000	7.94	--	--	--
	1/49	6		0.0	--	7.02	57.0	2.1	121,500	7.70	355	163	.037
	2/49	9		0.1	23	7.62	62.0	14.2	230,000	7.70	332	133	.040

TABLE 24 (Continued)

Sampling point mileage	Month /Year	No. of sam-ples	Dis-charge sec.-ft.	Averages					Median coliform M.P.N. per 100 ml.	Average chemical determinations			
				Temp. °C.	Tur-bid-ity, ppm.	Dissolved Oxygen ppm	Dissolved Oxygen % Sat.	5-day BOD. ppm.		pH	Alka-lin-ity, ppm.	Hard-ness ppm.	Copper ppm.
Cache La Poudre River (Continued)													
CLP 9.0	10&11/48	7	No data available at this time	6.5	--	2.95	18.2	119.8	68,000	7.60	--	--	--
	12/48	6		1.3	--	9.79	82.0	7.7	68,000	8.05	--	--	--
	1/49	6		0.0	--	9.96	81.0	1.6	9,300	7.90	356	113	.036
	2/49	9		0.4	36	9.81	80.0	4.0	430,000	7.80	334	103	.036
CLP 4.3	10&11/48	6		9.0	--	1.82	16.4	122.4	11,000,000	7.30	--	--	--
	12/48	9		1.4	--	7.65	64.1	48.7	930,000	7.80	--	--	--
	1/49	7		0.5	--	9.45	78.0	34.7	930,000	7.70	315	136	.059
	2/49	9		3.4	49	10.07	89.6	33.5	930,000	7.70	316	116	.045
CLP 2.6	10&11/48	6		10.5	--	1.56	14.2	130.8	4,300,000	7.60	--	--	--
	12/48	9		1.1	--	6.92	57.55	34.6	930,000	7.80	--	--	--
	1/49	7		0.6	--	8.80	72.0	21.0	750,000	7.70	323	133	.044
	2/49	9		2.8	42	8.52	74.4	21.1	430,000	7.70	317	122	.039
Timnath Reservoir Inlet													
	2/49	1		1.0	--	1.60	13.0	23.4	73,000	7.30	--	--	--

(50)

TABLE 25

Contribution of Denver Sewage to Flow of South Platte River Under Maximum, Minimum, and Average Flow Conditions 1945

Month 1945	Average Sewage Flow 1945 1000 A.F.	Runoff South Platte River 1945 1000 A. F.			Percent Sewage in Flow		
		Max.	Min.	Average	Max. Stream flow	Min. Stream flow	Average Stream flow
January	4.92	25.92	7.02	12.52	19.	70.	28.6
February	4.48	28.28	6.58	11.58	15.8	68.	38.7
March	4.96	61.26	8.26	15.96	8.1	60.	31.5
April	5.12	206.82	9.02	33.32	2.48	56.8	15.9
May	5.31	253.7	15.61	59.71	2.10	35.1	8.89
June	5.25	234.25	16.65	56.25	2.24	31.6	8.79
July	5.51	74.71	12.01	38.51	7.37	45.5	14.3
August	5.30	147.0	12.50	39.70	3.61	42.4	13.3
September	5.76	63.06	10.16	23.06	9.12	56.7	25.0
October	5.74	59.84	9.54	18.84	9.59	60.1	30.5
November	5.54	45.54	10.34	16.34	12.2	53.6	33.9
December	4.77	28.07	8.17	13.67	17.0	58.4	34.9

area above Kersey and are only for winter conditions. There are no results available for the 200 mile stretch from Kersey to North Platte or for the stream above Littleton or on the upper reaches of the tributaries. Further, no results are available to show quality of water during the irrigation season.

Hydrometric data are yet to be computed. There is always a lag in the obtaining of stream flow data because of the nature of the work and procedures involved.

This report, therefore, can do little except state the progress to date, and to point out the problems still to be considered which may lead to desirable changes in original objectives, or to a revaluation of these objectives.

The main objectives are still the determination of the extent, types, and sources of pollution and their effects upon the sanitary quality of water used for irrigation and other purposes, and the collection of epidemiological data. It would appear here that the major effects of pollution in the South Platte basin would be those relative to the use of water for irrigation purposes.

Water Supplies: -

Although 23 communities, including Denver and Cheyenne, utilize surface sources for their municipal water supplies, these supplies, except for a few instances, are derived from the sparsely populated headwaters of streams tributary to the South Platte or from the headwaters of the South Platte itself. The problems inherent in the use of highly polluted waters for public water supplies do not enter this investigation to any extent, as none of the communities below points of serious pollution utilize the stream waters for public water supplies. The waters considered for transmountain diversions or those diverted from the west slope for water supply purposes are from sparsely populated areas in the headwaters of the Colorado River system, and are not known to be highly polluted.

Table 20 outlines the present surface water supplies in the basin. The Denver supply utilizes waters from the upper Colorado Basin by the Moffat diversion and is seeking an additional 49,000 acre-feet yearly from the proposed Blue-South Platte diversion via the Montezuma Tunnel to North Fork of the South Platte River. Twelve of the communities using surface waters, including Denver and Cheyenne, have filter plants. Two of these supplies are inadequate. The remaining communities utilize untreated or partially treated surface waters. The filtering of all surface water supply is considered good public health practice because of the possibility of chance contamination.

Irrigation: -

The appropriation of the stream flows in the basin for agricultural use, particularly for irrigation, presents a number of problems not usually found in stream pollution investigations. These problems are largely the result of diversions of stream flows from the main channels into canals or ditches for irrigation purposes concurrently with the use of the streams for the disposal of wastes from communities or from industries. Where large volumes of sewage are contributed in proportion to the stream flow, conditions may be brought about similar to those found where broad irrigation is used as a method of sewage disposal. As a matter of fact, such conditions may be found to a greater or lesser extent below Denver, Golden, Greeley, Boulder, Ft. Collins, and Cheyenne, where irrigation diversions are made immediately below the communities. When stream flows are low, the sewage flow forms a large part of the water diverted immediately below the community for irrigation purposes. Table 25 shows the percentage of the flow of the South Platte contributed by the sewage from Denver for the year 1945 which was an average year from the standpoint of precipitation (13.58 ins.). During times of minimum runoff during the irrigation season, May to October, Denver sewage accounted for from 30% to 70% of the total flow below the city. Stream flows are diverted immediately below the west bank outfall for irrigation purposes by the Burlington-O'Brian ditch on the east bank, and by the Gardener's Ditch on the west bank a half mile or so downstream from the outfall. The visual effects of these diversions are apparent to anyone following the ditches. Laboratory results show that during the winter months, water diverted by the Burlington-O'Brian ditches to Barr Lake for irrigation storage is highly polluted and near septic conditions are present at the inlet to Barr Lake. Samples from the river below the Gardener's inlet (Station 295.5), or at Welby (Station 290.5), or at Ft. Lupton gage (Station 272.2) do not show similar conditions in the main stream, perhaps because of increased dilution from inflow along the river. At the inlet to Barr Lake reservoir, large sludge beds are visible at low water in the inlet ditch and lake. Samples recently taken from the outlet end of the reservoir after the ice had melted indicated zero dissolved oxygen in the lake. No diversions have been made by other ditches immediately below Denver or below other communities where sampling has been in operation during the period covered by this report.

It is proposed to shift sampling to inlets of major diversion ditches and to maintain only a few control points along the streams after the advent of the irrigation season, and to follow several representative ditches to obtain data on the quality of water actually used for irrigation purposes. There is special concern for the rapidly expanding truck farming industry in the basin, which is primarily located immediately below Denver, but which is expanding northeastward and which is producing beyond local needs. Ever increasing amounts of truck crops are being shipped to other mid-western markets each year and, as these crops include salad vegetables usually eaten in the raw state, the implications of irrigation with sewage-laden waters are obvious. Should one major disease outbreak be definitely traceable to the use of vegetables irrigated with contaminated water, the entire industry in these regions might suffer serious economic loss.

Beet Sugar Wastes: -

Stream sampling was begun just prior to the initiation of the 1948 beet sugar campaign in the basin. The effects of the wastes were immediately apparent in the area under examination from the Greeley laboratory, the only one then in operation. Beet sugar factory wastes are not a problem concerning water usage for irrigation purposes, except where waters containing these wastes are diverted to storage reservoirs, because beet sugar processing operations are carried out during the winter months, usually from November to January, when irrigation of crops is not practiced. However, where waters containing beet wastes are diverted for storage, odor nuisance conditions are reportedly present about the reservoir areas and from the released waters in the spring. The 1948 season was abnormally short because of reduced beet planting in the basin that year. The short campaign was immediately followed by quite severe weather conditions so that observations on reservoirs in the Ft. Collins area, usually containing a large amount of beet wastes, were not possible until February. Further, the mobile laboratory unit was not available to the Ft. Collins area until after the season had ended.

In conjunction with the Great Western Sugar Company and the Colorado State Department of Public Health, beet wastes from two plants (one Steffans process and one straight run process) were examined at the Health Department laboratory at Denver. Results are presented in Table 26.

Most of the sugar factories in the basin have lagoons for retention of wastes before discharge into the watercourses. It would appear from observation that these lagoons are not being operated satisfactorily, and that they are, therefore, not very efficient. It would seem to be of some benefit if separation of the dilute flume and wash waters from the stronger wastes could be achieved, so that the lagoon capacity could then be made available for retention of the stronger waste waters and those with high solids content. The problem of wastes disposal is complicated by the fact that the factories have only non-consumptive use rights to waters obtained from surface sources and they are required, therefore, to return water to the stream in amounts equivalent to those diverted for plant use. Water for consumptive use is either supplied from ground water sources or purchased from others with consumptive rights such as a public water supply. Waste disposal processes which lead to consumptive use of water may therefore greatly increase manufacturing costs, or lead to litigation with prior water users for consumptive water rights. The Great Western Sugar Company has indicated to the Colorado State Department of Health that they will use their factory at Windsor for experimental operations in beet wastes disposal during the 1949 season.

Reservoir Releases: -

One of the original objectives of this survey was to evaluate and determine required reservoir releases for:

1. Public water supply needs; and,

2. Sanitation purposes, including pollution abatement.

TABLE 26

SUGAR BEET WASTES

Windsor Plant

	November 16		November 18		November 20		
	BOD*	pH	BOD*	pH	BOD*	pH	Average BOD*
Silo Drainage	9760	3.90	8220	3.95	9931	4.05	9324
Pond Influent	638	7.18	828	7.21	892	7.80	786
Pond Effluent	604	6.30	626	6.70	853	7.50	731

Fort Collins Plant

	November 8		November 10		November 12		
	BOD*	pH	BOD*	pH	BOD*	pH	Average BOD*
Steffans Waste	8660	12.24	8540	12.05	10680	12.42	9393
Outlet Cinder Pond	274	6.34	268	6.25	464	5.87	335
Pond Influent	2070	11.31	2890	10.50	2980	11.17	2646
Pond Effluent	1550	7.52			1700	8.18	1625
Flume Wash Water			247	6.25	297	5.98	272

* 5-day 20° C.

Sufficient data are not presently available to include such estimates in this interim report. For the most part, surface water supplies are obtained from the headwaters of the various streams in the basin. The amount of water available to any given community for municipal use is dependent upon its claims to stream flows, and is based upon its adjudicated rights, together with its exchange agreements and purchases of water from other owners. These are all somewhat complicated factors which require additional study.

Water releases for sanitation purposes, including pollution abatement, raises a point as to whether or not it is possible to provide water for such purposes unless the releases can be made sufficiently close to the point of need to be effective. Where reservoirs are located some distance above the point of need, it is quite possible that all of the augmented water will be taken by intervening diversions to satisfy claims of other users. Even when releases are made during the winter when irrigation is not practiced, claims for water to fill reservoirs may absorb the increased flows. This, however, does not preclude the beneficial effects of augmented stream flows due to increased return flows resulting from additional water available for irrigation purposes. These return flows will probably increase substantially when water is available to the basin from the Colorado-Big Thompson and the Blue-South Platte projects. Completion of these two projects will increase the present water resources by some 700,000 acre-feet annually. Present return flows to the streams in the basin average from about 5 second feet per stream mile to as high as 7 to 10 second feet per stream mile. These figures have remained relatively constant over the past 20 years or more according to available information. It is anticipated that return flows will increase gradually as the Colorado-Big Thompson project is completed and placed into operation, and that they will become stabilized after water usage to the limit of all available resources has been achieved. Should the Blue-South Platte Project be constructed, there will be another similar period of adjustment following completion of that project. Table 27 lists all reservoirs under construction or contemplated for the Colorado-Big Thompson and the Blue-South Platte Projects.

A further complicating factor in possibly increasing reservoir releases is that, as far as the Colorado-Big Thompson project is concerned, design and construction features have gone beyond the point of permitting changes in reservoir capacities or locations. Some consideration may be given to operational procedures so as to permit slight variations in stream flows.

The Blue-South Platte Project, on the other hand, is still in the planning stage. Reservoir locations and sizes have been decided upon, but it still may be possible to make some changes in the designs, if necessary, to provide for additional water for sanitation purposes. Water releases from this project are possibly more important than from the Colorado-Big Thompson project, as such extra water would serve to mitigate the pollution problem below Denver. Further, such releases would have an excellent chance to reach the point of need as there are few diversions on the South Platte above Denver other than those for the Denver water supply system.

TABLE 27

Reservoirs in Operation or Contemplated for Various Projects Affecting South Platte Basin

Reservoir	Capacity A-f	Project	Status 1/	Est.Start Construc.	Est.Complete Construc.	Agency	
Green Mountain	146,888	C.B.T.3/	C	----	1938	BR	--Blue River
Granby	462,900	"	U/C	----	1950	BR	--Colorado
Shadow Mountain	18,300	"	U/C	----	1950	BR	--No.Fork Colorado
*Mary's Lake	1,149	"	C	----	1949	BR	--Thompson
*Estes	2,855	"	C	----	1949	BR	--Thompson
*Carter Lake	110,000	"	P	1950	1953	BR	--Little Thompson
*Horsetooth	146,000	"	U/C	----	1952	BR	--Soldier Creek
*Flatiron	19,000	"	P	1950	1952	BR	--Cottonwood Creek
Pando	62,000	B.S.P.4/	P	1959	1965	BR	--Eagle River
Tenmile	141,500	"	P	1951	1955	BR	--Ten Mile Creek
Blue	40,000	"	P	1953	1956	BR	--Swan River
Snake	272,000	"	P	1957	1963	BR	--Snake River
Shawnee	50,000	"	P	1959	1963	BR	--N.Fork South Platte
Two Forks	422,000	"	P	1952	1957	BR	--South Platte
*Chatfield	280,000	"	P	----	1966 2/	USCE	--South Platte
Empire	77,000	"	P	1964	1967	BR	--Clear Creek
*Cherry Creek	185,000	"	U/C	----	1958 2/	USCE	--Cherry Creek
Ruedi	100,000	"	P	1952	1956	BR	--Fryingpan River
Piney	24,300	"	P	1965	1968	BR	--Piney River
Turkshead Afterbay	1,770	"	P	1954	1956	BR	--South Platte River

* On east slope of divide feeding directly to South Platte River System.

1/ C - Construction Complete
P - Potential Reservoirs
U/C - Under construction

2/ Dates when Bureau has scheduled completion of necessary irrigation works.

3/ Colorado-Big Thompson

4/ Blue-South Platte

Review of State Water Pollution Laws: -

The following information relative to the water pollution laws of Colorado, Nebraska and Wyoming is quoted from review memoranda prepared by the Office of the General Counsel, Federal Security Agency. In view of the limited time for review and the absence of any opportunity for consultation with persons familiar with the actual operation of the existing statutes in these states the recommendations and suggestions given by the Assistant General Counsel preparing this review are necessarily quite tentative.

"Colorado-

"I. Chapter 208 of the 1947 Session Laws of Colorado places water pollution control activity under the State Department of Public Health. No specific statutory provision is made for the administrative establishment of a water pollution control authority, but the State Department of Public Health is given the power and duty in section 5(7)

> 'to establish and enforce minimum general sanitary standards as to the quality of water supplied to the public and as to the quality of the effluent of sewerage systems and trade wastes discharged upon the land or into the surface or ground waters . . . and to advise with municipalities, utilities, institutions, organizations and individuals, concerning the methods or processes believed to be best suited to provide the protection or purification of water and the treatment of sewage and trade wastes to meet such minimum general sanitary standards.'

In order to meet the foregoing and other allied statutory duties the Department of Public Health has, in fact, established an Environmental Sanitation Division which has responsibility for water and sewage sanitation in addition to milk, bedding, restaurant, food and drug and general sanitation, industrial hygiene and plumbing inspection.

"Legislation reorganizing the State Department of Public Health was passed in 1947. At that time the decision was evidently made to eliminate such detailed reference to water pollution control activity as was present in the former statutes, and to leave the particulars of water pollution prevention, abatement and control to regulations or orders to be promulgated by the Department of Public Health. The Department is given authority by statute to hold hearings, issue regulations and orders and seek court enforcement for violation of its orders and regulations.

"While we would prefer to see statutory duties imposed in more detail than obtains in this case, in order to put the water pollution control authority under a specific mandate to carry forward a minimum program, we realize such an approach may be unrealistic in view of the recent legislative reorganization of the Department of Publich Health.

"In the absence of legislative changes spelling out the duties of a water pollution control authority, we suggest that consideration be given to the tentative criteria (see Appendix "E") developed by this office in consultation with the Division of Water Pollution Control of the Public Health Service by the Department of Public Health in the drafting of their regulations.

"However, the present statute may impose some limitations on the Department of Public Health which will not permit it to adopt some of the suggested criteria into its regulations.

1. The Department of Public Health is given the power and duty

> 'to establish and enforce minimum general sanitary standards . . . as to the quality of the effluent of sewerage systems and trade wastes discharged upon the land or into ground or surface waters.'
> (Ch.78, section 21 (5)(7) Colorado Statutes Annotated, 1947 Supp.)

Our suggested criteria gives the State water pollution control authority the statutory power and duty to set standards of water purity and classify waters according to their particular uses. The setting of a 'minimum general sanitary standard' may prove so rigid as to seriously deter adequate water pollution control and this limitation should be eliminated from the statute.

2. The State water pollution control authority may wish to cooperate with other States. Such authorization should be specifically granted in the statute.

3. The only definitions found in the act are in section 5 (20), and define two terms 'minimum general sanitary standards' and 'standards'. At a bare minimum it might also be advisable to define 'trade wastes' (see section 5(7)). In view of the large mining operations in the State, it should be made clear whether 'trade wastes' includes mining wastes.

"Nebraska-

"The only statutory authority for water pollution prevention abatement and control in Nebraska follows:

> 'The Department of Health shall have general supervision and control over matters relating to public health and sanitation . . .' (81-601 Revised Statutes of Nebraska)

"The official publication of the Nebraska Department of Health, the Almanac, 1949, offers the following water pollution control services:

1. Reviewing of plans and specifications and inspecting of all construction relative thereto: public and semi-public water supplies; sewage disposal works; swimming pools.

2. Making routine field inspections and rendering consultative

services as needed in the above fields of public works.

3. Certifying water supplies and coach yards for servicing of interstate carriers.

4. Making sanitary surveys, inspections and advising municipal officers on problems of garbage and refuse disposal.

5. Giving formal classroom instruction in sanitation at schools, colleges and universities.

"Nebraska does not have a comprehensive water control law. The functions of the Sanitation Division of the Department of Health are advisory and educational only. There is no statutory mandate for the development of a comprehensive water pollution control program or the administrative enforcement thereof.

"It is suggested that Nebraska enact comprehensive water pollution control legislation using the criteria contained the attached paper entitled "State Water Pollution Control Legislation." (See Appendix "E").

"Wyoming -

"Administrative Agency 1/. Administrative authority and responsibility are vested in the State Board of Health which has extensive powers. There are no exemptions from the jurisdiction of the State Board of Health provided for by the State statutes. However, the Indian Service assumes jurisdiction on Indian reservations for sewage disposal. Although an unsatisfactory situation is reported to exist within the *Wind River Indian Agency which has an effect on downstream population, the problem seems to lie outside the reach of State statutory action. An approach on a Federal agency level should be considered in relation to this problem. (See 17th Biennial Report, Wyoming State Board of Health, pp. 46-47)

"Investigations, rules, regulations, and orders. The State Board of Health may make investigations and issue orders, rules, and regulations. There is no provision for a hearing, but in conducting investigations the Board has the power to summon witnesses, administer oaths, and hear evidence, and the investigations may be conducted in the same manner as hearings. It is to be noted that the basic Act was passed in 1923. Since that time the value of conducting hearings has become more apparent. If any change in the statute is contemplated, consideration should be given to requiring hearings by statute unless they are already afforded by administrative action under the power to conduct investigations.

"Comprehensive program. There is no statutory mandate for the development of a comprehensive program, for the prevention, control and abatement of water pollution; such provision is deemed to be most

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1/ Relevant statutes are contained in S 63-112, 63-204, 201-212, Wyoming Compiled Statutes Annotated, 1945.

* Note. This condition has been corrected.

desirable, and should be considered if recommendations are to be made suggesting statutory changes.

"Cooperation and Federal aid. There is no specific statutory authority to cooperate with other States and the Federal Government. However, a pattern of cooperation with Federal agencies seems to be indicated by the biennial reports of the Wyoming Board of Health. It may be deemed desirable to provide by statute for such cooperation with the Federal Government and other States in the development of a comprehensive program.

"It is understood that no action was taken at the last legislative session in Wyoming (adjourned February 19, 1948) on the Council of State Governments' water pollution control enabling act. It should be ascertained that all necessary action has been taken to secure to the State the benefits of the Federal Water Pollution Control Act.

"Plans and specifications. Review and approval of plans and specifications by the Board of Health is provided by statute. Anyone operating a railroad, logging road, logging camp, electric plant, manufacturing or industrial plant of any kind upon or over any watershed of any public supply system is subject to these provisions.

"Complaints. The Board of Health is required to investigate complaints of the mayor or health officer of any city or town or the managing board or officer of any public institution or the president of an ice company relating to pollution of water used as a source of water supply used by them. It is suggested that the class of people who may make such complaints be enlarged and that complaints be required to be investigated if they relate to pollution, even though such pollution does not affect one of the limited sources of water supply now enumerated in the statute.

"Classification of waters. There is no statutory mandate for the setting of standards of water purity and the classifying of waters according to their particular uses. Presumably this may be done under the present authority to issue regulations, however, a statutory mandate to this effect may be considered.

"Enforcement. Adequate investigatory powers, sanctions, legal action, and judicial review appear to be provided for by statute."

PERSONNEL ENGAGED ON THE SURVEY

The following personnel were engaged on this investigation as of March 1, 1949:

1. Public Health Service Personnel (Full Time):

Public Health Engineer C. T. Carnahan (Denver)
Asst. Sanitary Engineer I. P. Sander (Denver)
Chemist J. M. Cohen (Greeley Laboratory)
Bacteriologist W. R. Van Nattan (Trailer Laboratory)
Laboratory Aides, SP-5 (2)
Automotive Mechanic, CPC-5, Sample Collector (Trailer Laboratory)
Clerk-Stenographer, CAF-4 (Denver)

2. State Personnel (Colorado Health Department and Game and Fish Dept.):

Chemist P. W. Jacoe (Part Time)
Chemist J. D. Torrey (Part Time)
Chemist Elaine O'Brien (Part Time)
Bacteriologist Dr. G. W. Stiles (Part Time)
Motor Vehicle Operators II, Sample Collectors (2) (Denver and Greeley) (Full Time)

ACKNOWLEDGMENTS

Acknowledgment is made of the invaluable aid contributed by the Denver District Office, U. S. Corps of Engineers from whose data sources much of the basic descriptive materials of the South Platte River Basin were taken. (House Document No. 669, 80th Congress, 2nd Session, May 30, 1948).

It is desired to acknowledge the aid contributed by the various Bureau of Reclamation offices; the Colorado State Department of Public Health; the Colorado Game and Fish Department; the City and County of Denver; the State Engineer of Colorado; the Region 9 Office, Public Health Service; the City of Greeley; the Weld County Health Unit; the Colorado A & M College; the Great Western Sugar Company; and all others who have contributed directly, or indirectly, to the progress of this survey to date.

RECOMMENDED ADDITIONAL STUDIES

1. A study of the presence and disposition of enteric pathogens in irrigation waters should be undertaken. A study designed to evaluate the relationships between degree of pollution of irrigation water and degree of pollution of crops irrigated with this water should also be made. Additional important bacteriological studies which should be undertaken include: a study of the use of pollution indicator organisms other than the coliform group and a study of the changes in degree of bacterial contamination of vegetables and surrounding irrigated soil with time, under various weather conditions, using the coliform group and possibly other organisms as indicators of sewage contamination.

2. A study of the state laws and legal decisions concerning water rights and the appropriation and usage of waters for various purposes in the states of Colorado, Wyoming, and Nebraska. Such a study would

probably be of immense value in the preparation of the final report on this survey, especially in the determination of the possibility of water usage for sanitation purposes and for pollution abatement.

3. A study involving the use of colored photographs by means of which the effects of diversions and stream channel flows may be determined. Such a study is indicated below Denver where varying stream flow conditions divert the sewage plant effluent to different irrigation ditches. Similar studies are indicated below Boulder, Greeley, Ft. Collins, Golden, and possibly below discharges of industrial wastes or other direct sources of pollution. The use of indicator dyes is suggested to bring out the picture clearly. It is believed that such a study would be of immense benefit in working out the complex stream flow diversion picture in this basin, especially as a comprehensive pollution survey on a stream of this type has not been carried out before. Contacts have been made with the Photographic Section, Air Force Training Center, Lowry Field, Denver, Colorado, and they are agreeable to the study and are willing to photograph stream sections below designated points at low altitudes so as to record the flow patterns produced by the wastes after they are discharged into the streams. The Colorado State Department of Public Health is also interested and will cooperate closely with us on such a study.

PROPOSED PROCEDURES FOR CONTINUATION OF THE INVESTIGATION

It is proposed to carry on the survey under present methods through June 30, 1949, and until at least January 1, 1950, if funds can be obtained, in order to complete collection of data on the pollution of the South Platte Basin and its relationships to irrigation and other water usages. Such a program will obtain data over one full yearly seasonal cycle. If possible, observations should be continued with laboratories at Greeley and at Denver, supplemented by the mobile laboratory to cover the remainder of the basin. Laboratories at Greeley and Denver are important, as these two places are well located for observations on the greatest pollution problems and on the quality of irrigation water.

It is proposed to gather all necessary data on the sources of pollution in the basin, including types and location of pollution discharge.

It is proposed to determine the sanitary quality of water used for irrigation by taking water samples at representative diversion points during the irrigation season.

It is proposed to carry on the special bacteriological studies previously mentioned under "Recommended Additional Studies" to as great an extent as possible in conjunction with the regular pollution survey work. This activity will require the services of at least one additional bacteriologist.

An epidemiological study relative to the use of sewage-polluted waters for irrigation purposes will be made. There are at present only limited suggestive data relative to the increase in incidence of enteric diseases which may be due to the consumption of raw salad vegetables irrigated with sewage-polluted waters. In this connection, attention is invited to the epidemiological report furnished by the Colorado State Health Department (Appendix "E"). This report indicates an outbreak of 250 cases of bacillary dysentery traceable to the consumption of raw cabbage harvested from farms near Denver where sewage-contaminated water had been used for irrigation. There is considerable economic justification for such an epidemiological study. At the present time, truck crops are being shipped from this area in increasing volume. Celery is a major export crop from this vicinity. Several thousand cars of this and other truck crops are shipped from this region every year. Sale of this produce is hampered in areas where it is known that the waters used for irrigating these crops contain sewage or sewage effluents. Should a disease outbreak either actually or presumptively implicate vegetables grown in this region and irrigated with sewage-polluted waters, it would result in serious losses to truck farmers of the region. A study of the epidemiological factors involved in the use of sewage-polluted irrigation waters, especially those involving raw sewage and primary treatment effluents, is indicated for the protection and maintenance of the rapidly expanding truck farming industry in the South Platte valley. There are also other factors involved in the use of polluted irrigation waters which include the possible transmission of animal diseases and the pollution of shallow ground waters which are used in some areas as the source of farm water supplies. There are also the problems inherent in the direct use of ditch water for general farm purposes. Where ground waters are highly mineralized, ditch water may be used either directly from the ditch, stored in cisterns, or else shallow infiltration wells are dug closely adjacent to the ditches. The role of soils contaminated by irrigation with sewage laden waters in the possible spread of disease and as a contributory factor in the pollution of surface runoff is a possible factor warranting investigation.

The Colorado State Department of Public Health is interested in the conduct of a comprehensive epidemiological study on the relationships between incidence of enteric disease and the use of waters containing sewage or sewage effluents for the irrigation of truck crops, especially those often eaten in the raw state. State health officials feel that such a study would be of great benefit to the arid and semi-arid states and would serve to clarify the present confusion with regard to the setting of limits on the use of sewage-polluted waters for irrigation purposes. A summary of presently available epidemiological data, prepared by the Colorado State Health Department, is given in Appendix "F".

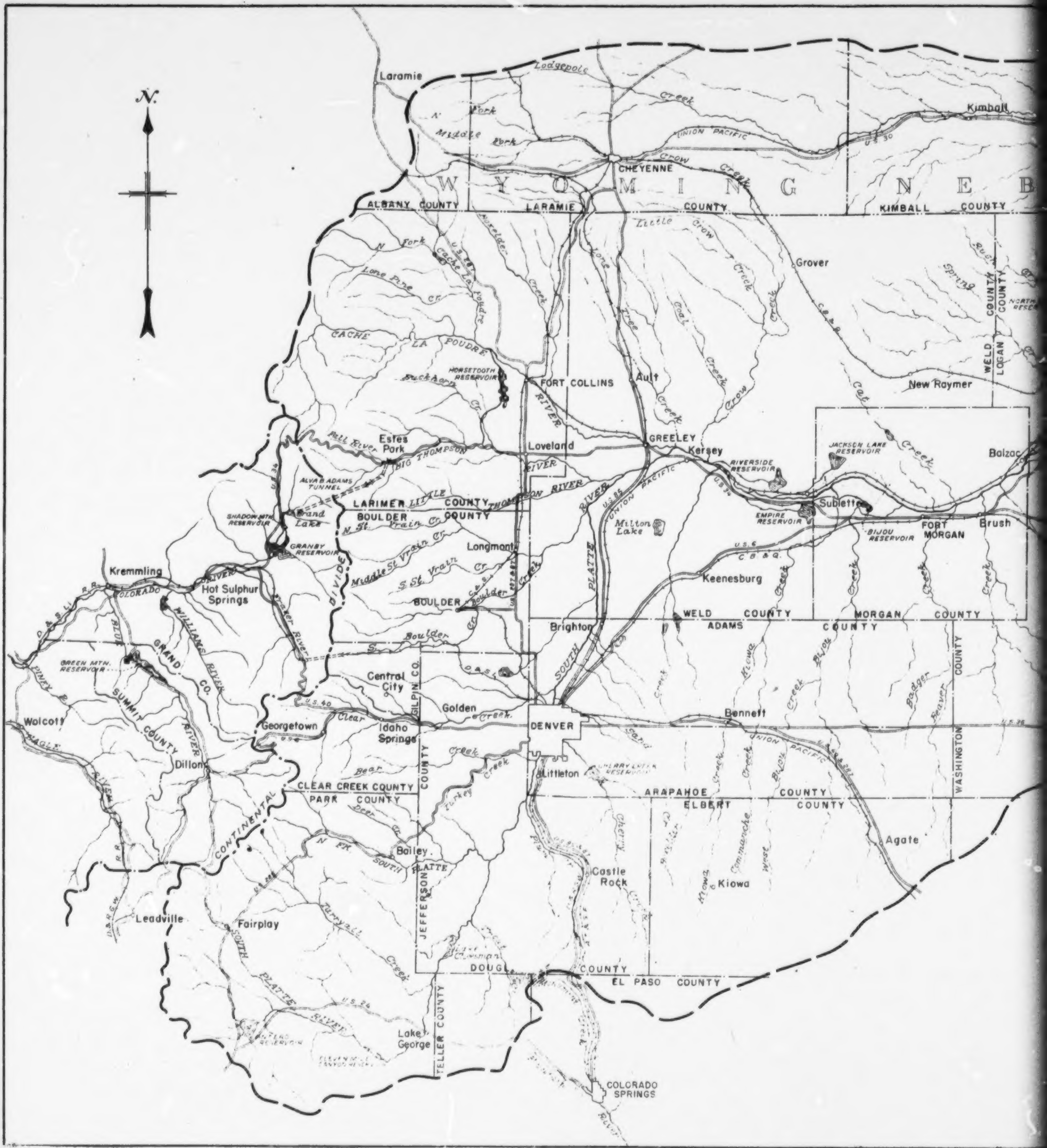
A brief, annotated bibliography on the public health aspects of the use of sewage-polluted irrigation waters is given in Appendix "G".

FIGURES

South Platte River Basin

Water Pollution Investigation

Figure	Title
1	South Platte River Basin (Colorado-Wyoming-Nebraska)
2	Irrigation Division No. 1 - State of Colorado - Location of Water Districts
3	Diagram Showing Location of and Distances Between Ditches from the South Platte River - Antero Reservoir to Kersey
4	Diagram Showing Location of and Distances Between Ditches from the South Platte River - Kersey to Balzac
5	Diagram Showing Location of and Distances Between Ditches from the South Platte River - Balzac to Julesburg
6	General Map of Entire Denver Water System Present and Proposed
7	South Platte River and Tributaries - Laboratory Data - Sources of Pollution - Surface Water Supplies - Trans-Mountain Diversions - Irrigation Water Diversions
8	Dissolved Oxygen Results at Sampling Stations
9	Bio-Chemical Oxygen Demand Results at Sampling Stations
10	Bacteriological Results at Sampling Stations



N.
Laramie
Lodgepole
Creek
N. Fork
Middle Fork
UNION PACIFIC
Kimball
U.S. 30
Crow
Creek
CHEYENNE
W Y O M I N G
N E B
ALBANY COUNTY
LARAMIE
COUNTY
KIMBALL COUNTY
N Fork
Cache La Poudre
Lone Pine Cr.
Little Crow Creek
Lone Tree Creek
Coal Creek
Crow Creek
Grover
C B & Q
Spring
WELD COUNTY
LOGAN COUNTY
CACHE LA POUDRE
HORSETOOTH RESERVOIR
Buckhorn Cr.
FORT COLLINS
RIVER
Ault
Cat Creek
New Raymer
Fall River
Estes Park
BIG THOMPSON
ALVA B. ADAMS TUNNEL
Loveland
RIVER
GREELEY
Kersey
RIVERSIDE RESERVOIR
JACKSON LAKE RESERVOIR
Balzac
U.S. 34
LARIMER
LITTLE
COUNTY
THOMPSON RIVER
BOULDER
COUNTY
SHADOW MTN. RESERVOIR
Grand Lake
N. St. Vrain Cr.
Middle St. Vrain Cr.
S. St. Vrain Cr.
GRANBY RESERVOIR
Longmont
UNION PACIFIC
U.S. 85
Milton Lake
EMPIRE RESERVOIR
Sublette
FORT MORGAN
Brush
BIJOU RESERVOIR
U.S. 6
C B & Q
Keenesburg
Kremmling
COLORADO RIVER
Hot Sulphur Springs
WILLIAMS
Fraser River
DIVIDE
BOULDER
Boulder Cr.
PLATTE
WELD COUNTY
ADAMS COUNTY
MORGAN COUNTY
Brighton
D. & S. L.
GREEN MTN. RESERVOIR
GRAND CO.
RIVER
S. Boulder Cr.
Central City
GILPIN CO.
SOUTH
Kiowa Creek
Bijou Creek
Badger Creek
Beaver Creek
WASHINGTON COUNTY
Piney R.
SUMMIT COUNTY
Wolcott
Eagle River
Georgetown
U.S. 40
Clear Creek
Golden
Idaho Springs
DENVER
Bennett
U.S. 36
UNION PACIFIC
Sand Creek
Dillon
Blue River
Bear Creek
Turkey Creek
Littleton
CHERRY CREEK RESERVOIR
CLEAR CREEK COUNTY
PARK COUNTY
JEFFERSON COUNTY
ARAPAHOE COUNTY
ELBERT COUNTY
Deer Cr.
CONTINENTAL
N. Fk. SOUTH PLATTE
Bailey
Plum Creek
Cherry Creek
Kiowa
Comanche Creek
West Creek
Agate
Castle Rock
Leadville
D. & R. G. W.
Fairplay
Tarryall Creek
SOUTH PLATTE RIVER
Cheesman
DOUGLAS COUNTY
EL PASO COUNTY
U.S. 24
ELEVENMILE CANYON RESERVOIR
Lake George
TELLER COUNTY
COLORADO SPRINGS

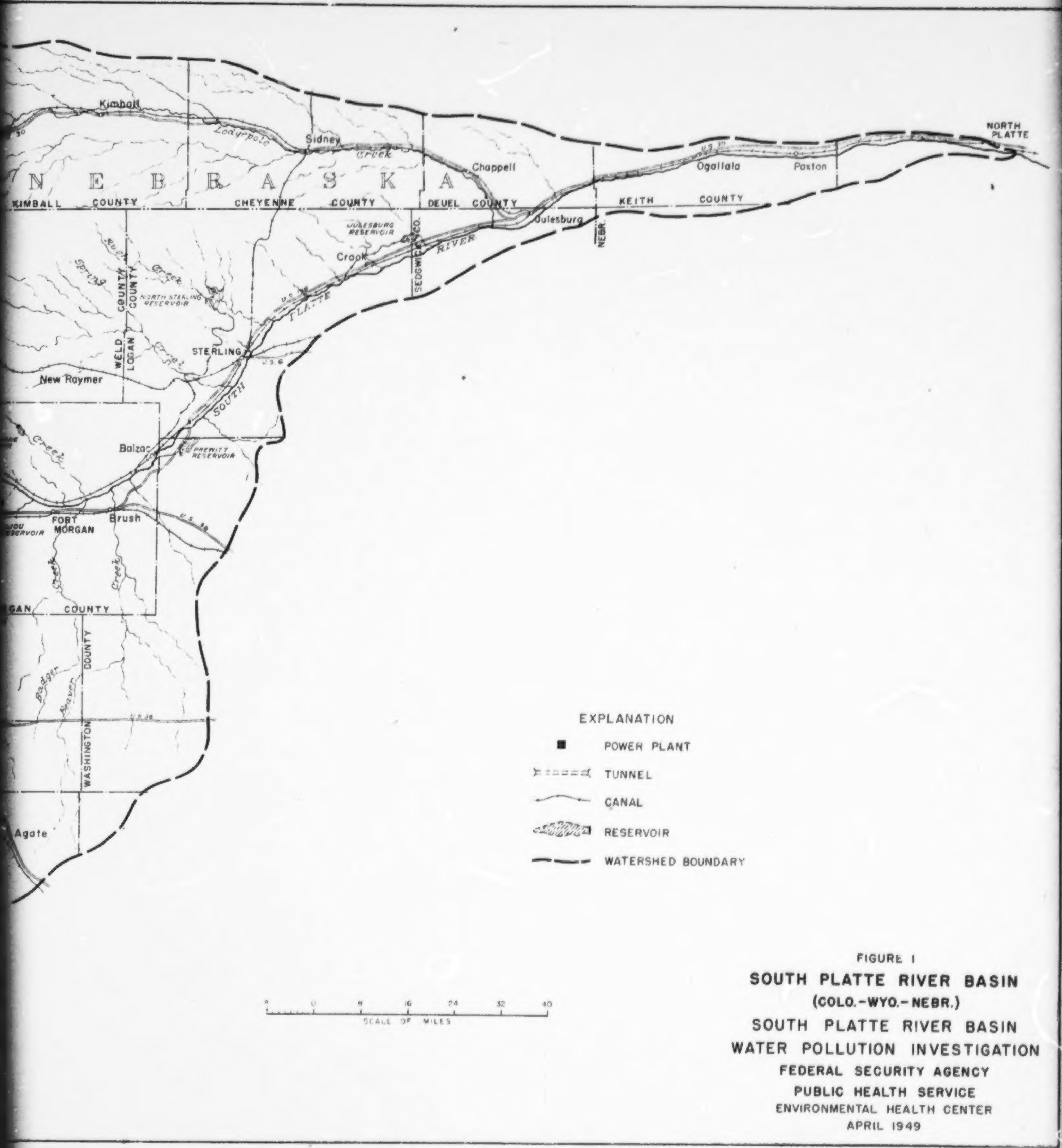
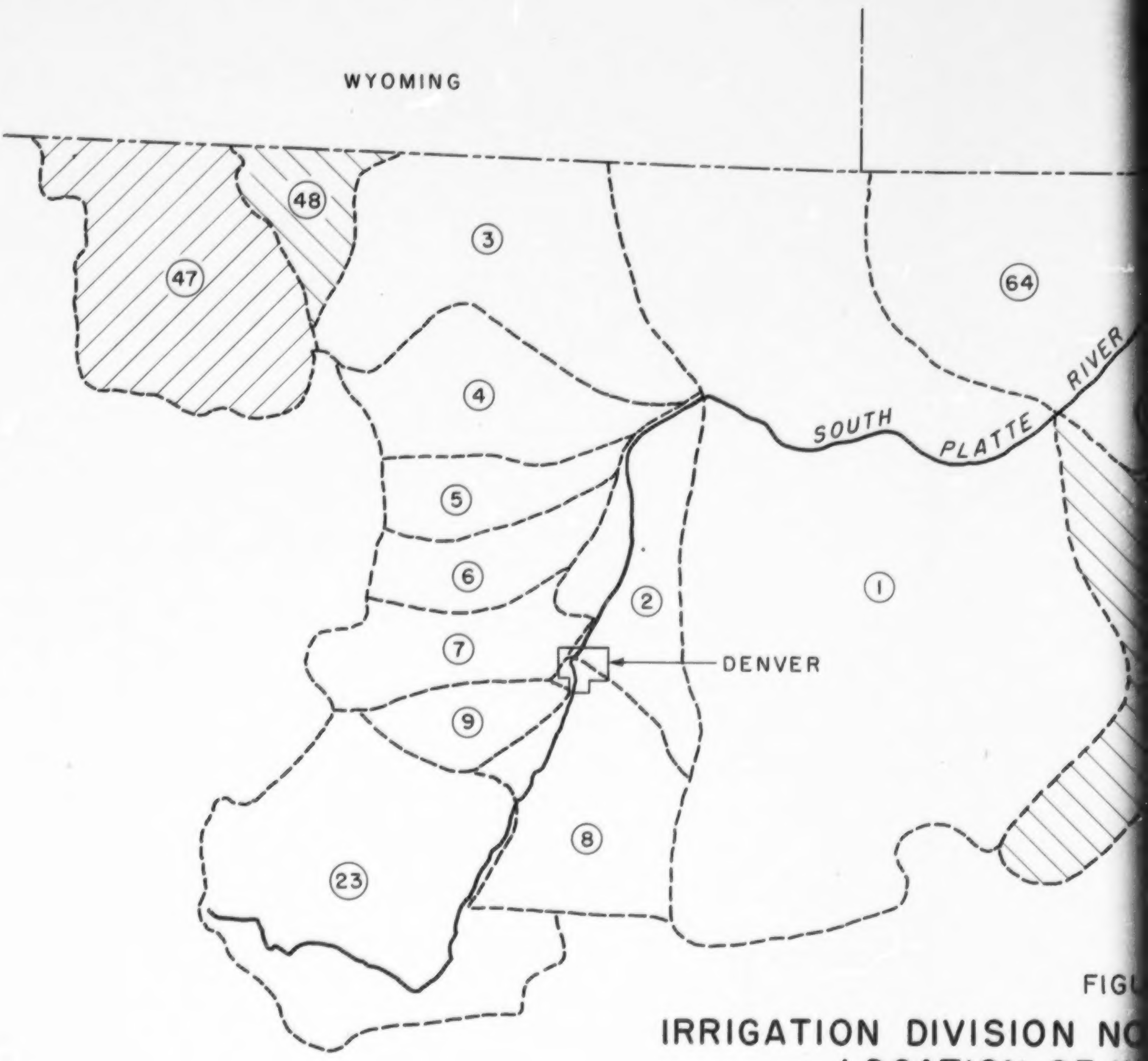

NEBRASKA
Kimball
Lodgepole
Sidney
Creek
Chappell
Ogallala
Paxton
NORTH PLATTE
U.S. 30
KIMBALL COUNTY
CHEYENNE COUNTY
DEUEL COUNTY
KEITH COUNTY
Julesburg
JULESBURG RESERVOIR
SEDGWICK CO.
NEBR.
Crook
SOUTH PLATTE RIVER
Spring
Creek
NORTH STERLING RESERVOIR
WELD COUNTY
LOGAN COUNTY
STERLING
U.S. 6
New Raymer
Creek
Balzac
PREWITT RESERVOIR
FORT MORGAN
Brush
U.S. 34
MORGAN COUNTY
Creek
Creek
Badger
Beaver
WASHINGTON COUNTY
U.S. 36
Agate
EXPLANATION
POWER PLANT
TUNNEL
CANAL
RESERVOIR
WATERSHED BOUNDARY
0 8 16 24 32 40
SCALE OF MILES

FIGURE I

SOUTH PLATTE RIVER BASIN

(COLO.-WYO.-NEBR.)

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
APRIL 1949


WYOMING
48
47
3
64
4
5
6
7
9
23
8
2
1
SOUTH PLATTE RIVER
DENVER

NOTE: Cross hatched areas
not in South Platte
River Basin.
Districts indicated by ○

FIGU

IRRIGATION DIVISION NO
LOCATION OF W

SOUTH PLATT

WATER POLLUTI

FEDERAL SEC

PUBLIC HEA

ENVIRONMENTAL

APRI

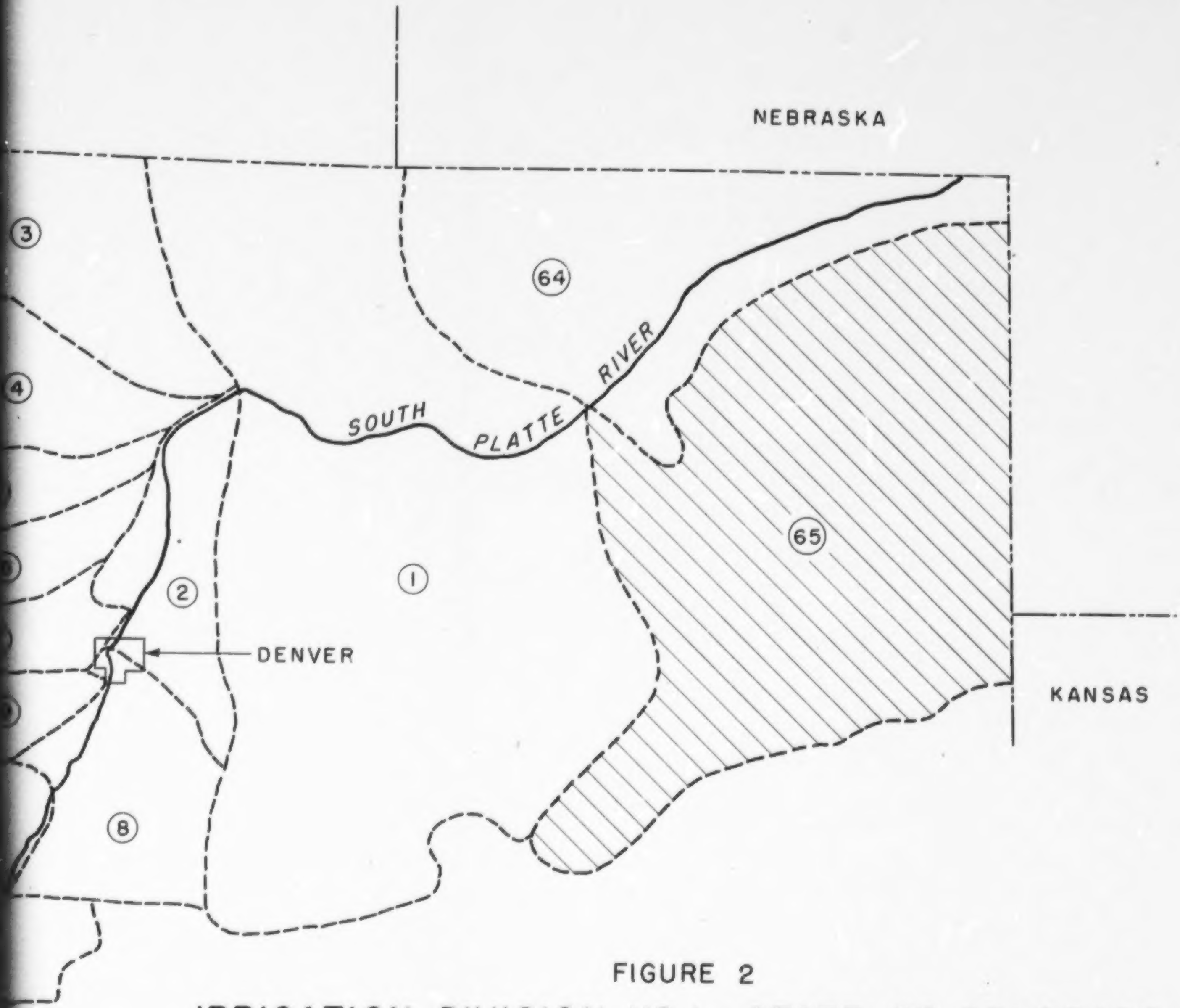

NEBRASKA
KANSAS
SOUTH PLATTE RIVER
DENVER
3
4
2
1
8
64
65

FIGURE 2

IRRIGATION DIVISION NO.1 – STATE OF COLORADO
LOCATION OF WATER DISTRICTS

SOUTH PLATTE RIVER BASIN

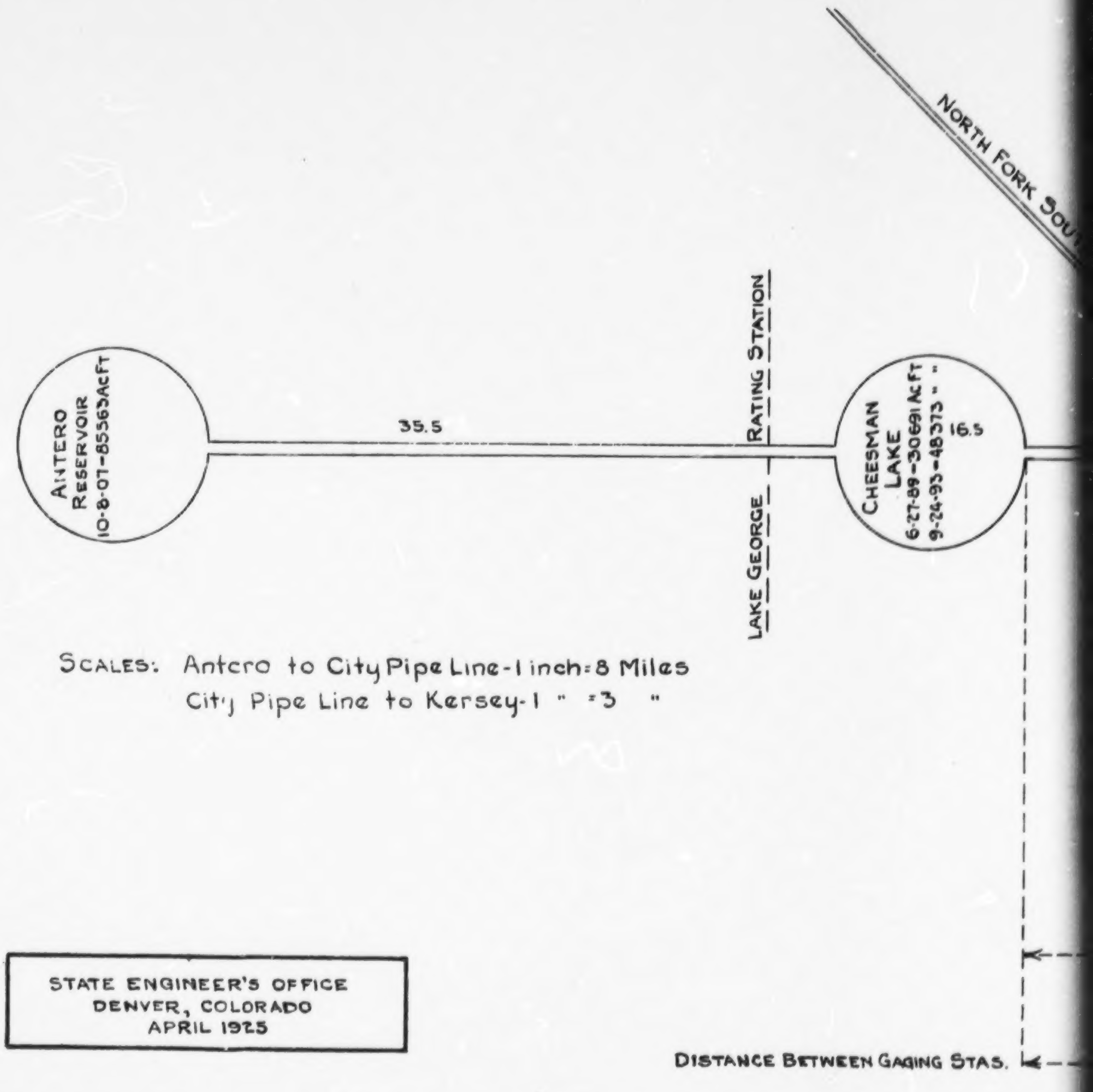
WATER POLLUTION INVESTIGATION

FEDERAL SECURITY AGENCY

PUBLIC HEALTH SERVICE

ENVIRONMENTAL HEALTH CENTER

APRIL 1949


ANTERO RESERVOIR
10-8-07-85563 Ac Ft
35.5
LAKE GEORGE RATING STATION
CHEESMAN LAKE
6-27-89-30691 Ac Ft
9-24-95-48373 " "
16.5
NORTH FORK SOU
DISTANCE BETWEEN GAGING STAS.

SCALES: Antero to City Pipe Line - 1 inch = 8 Miles
City Pipe Line to Kersey - 1 " = 3 "

STATE ENGINEER'S OFFICE
DENVER, COLORADO
APRIL 1925

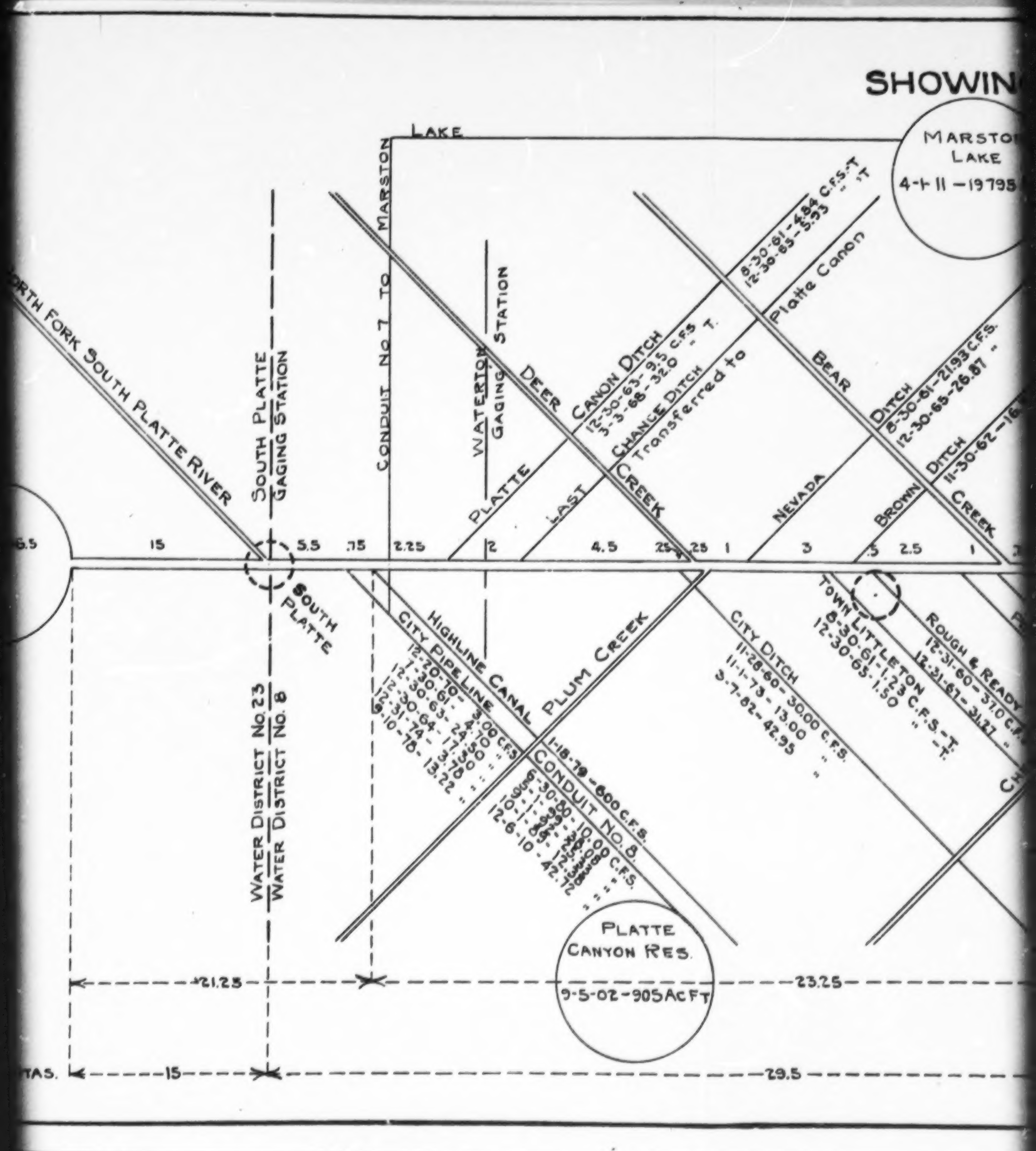
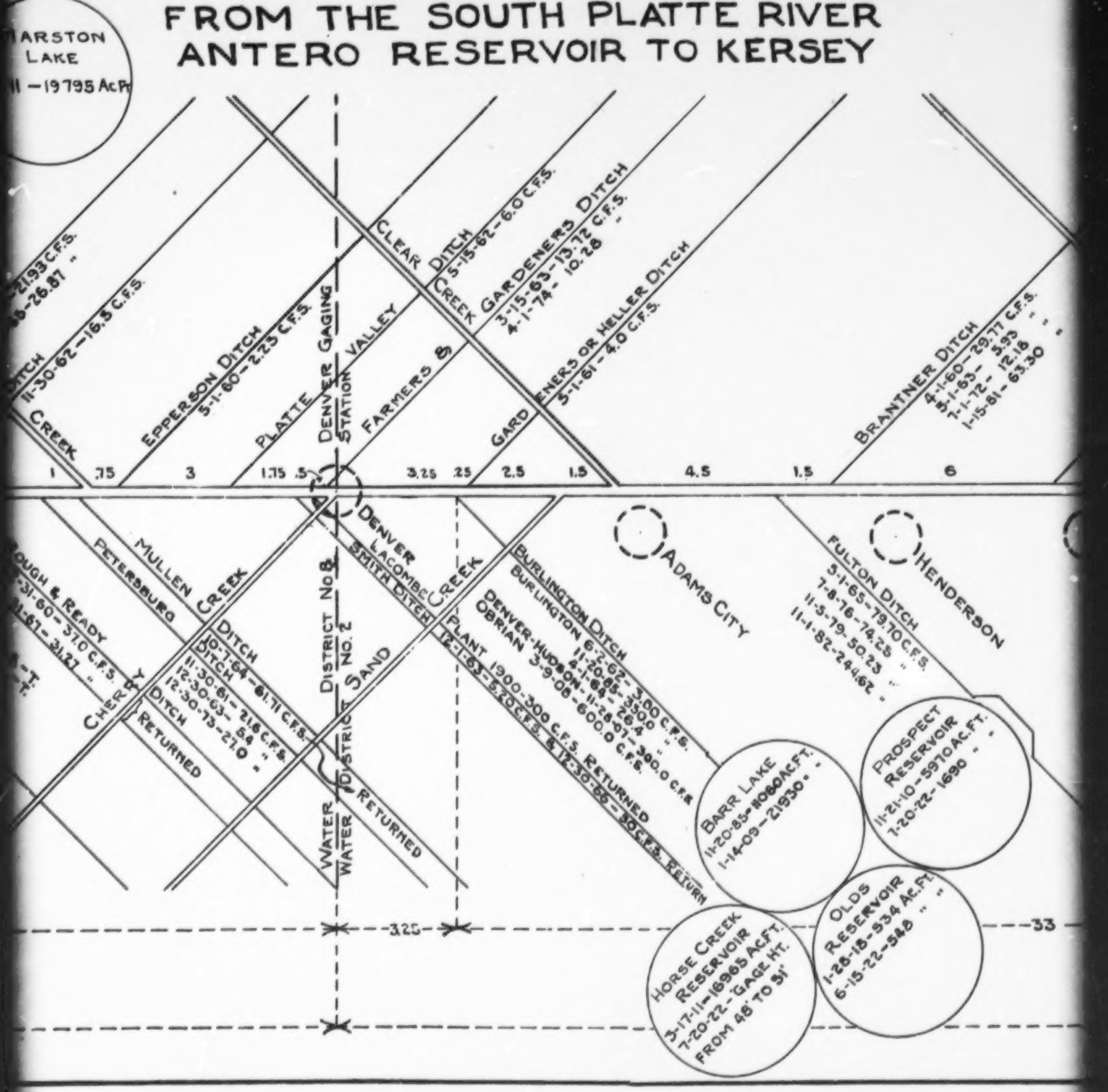
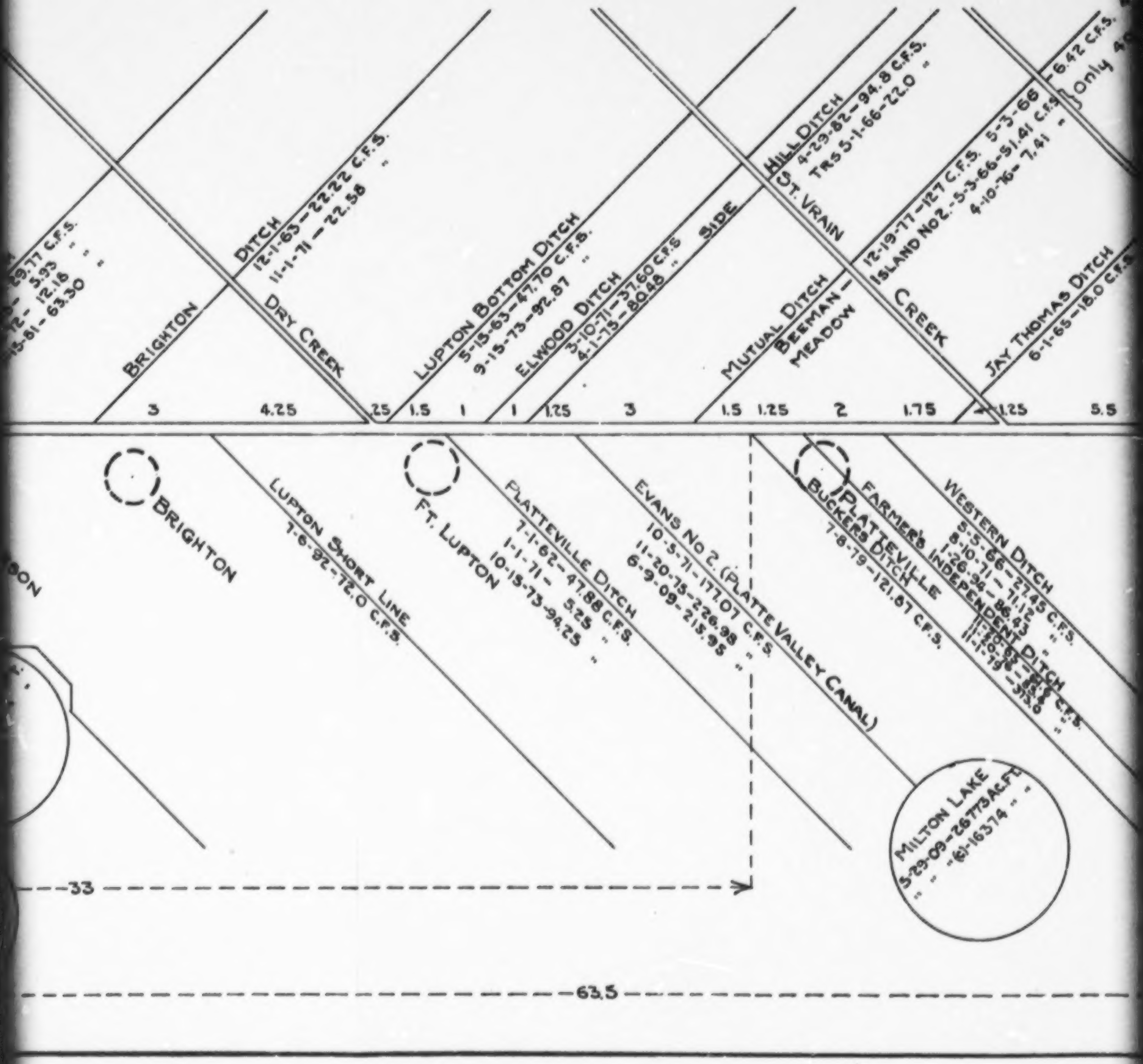

SHOWIN
MARSTO
LAKE
4-1-11 – 19795
LAKE
MARSTON
CONDUIT NO 7 TO
SOUTH PLATTE
GAGING STATION
WATERTON
GAGING STATION
ORTH FORK SOUTH PLATTE RIVER
PLATTE
DEER
CANON DITCH
12-30-63-9.5 C.F.S.
3-3-68-32.0 " T.
LAST
CHANCE DITCH
Transferred to
Platte Canon
8-30-61-4.84 C.F.S.-T
12-30-65-5.93 " -T
CREEK
BEAR
DITCH
8-30-61-21.93 C.F.S.
12-30-65-26.87 "
NEVADA
BROWN
DITCH
11-30-62-16
CREEK
6.5
15
5.5
.75
2.25
2
4.5
.25
.25
1
3
.5
2.5
1
SOUTH PLATTE
HIGHLINE CANAL
CITY PIPE LINE
12-20-70-3.00 C.F.S.
7-30-61-4.70 "
12-30-63-24.30 "
12-30-64-17.30 "
12-31-74-3.78 "
9-10-78-13.22 "
PLUM CREEK
1-18-79-600 C.F.S.
CONDUIT NO. 8.
6-30-80-10.00 C.F.S.
12-6-10-42.72 "
CITY DITCH
11-28-60-30.00 C.F.S.
11-1-73-13.00 "
3-7-82-42.95 "
TOWN LITTLETON
8-30-61-1.23 C.F.S.-T.
12-30-65-1.50 " -T.
ROUGH & READY
12-31-60-37.0 C.F
12-31-67-31.27 "
CH
WATER DISTRICT NO. 23
WATER DISTRICT NO. 8
PLATTE
CANYON RES.
9-5-02-905 AC FT
21.25
23.25
TAS.
15
29.5

DIAGRAM
WING LOCATION OF AND DISTANCES BETWEEN DITC
FROM THE SOUTH PLATTE RIVER
ANTERO RESERVOIR TO KERSEY


ARSTON LAKE
1 - 19795 Ac.Ft.
-21.93 C.F.S.
-26.87 "
DITCH
11-30-62 - 16.3 C.F.S.
CREEK
EPPERSON DITCH
5-1-60 - 2.23 C.F.S.
PLATTE
DENVER GAGING STATION
VALLEY
FARMERS &
CLEAR CREEK
DITCH 5-15-62 - 6.0 C.F.S.
GARDENERS DITCH
3-15-63 - 13.72 C.F.S.
4-1-74 - 10.28 "
GARDENERS OR HELLER DITCH
5-1-61 - 4.0 C.F.S.
BRANTNER DITCH
4-1-60 - 29.77 C.F.S.
5-1-63 - 3.93 "
7-1-72 - 12.18 "
1-15-81 - 63.30 "
1
.75
3
1.75
.5
3.25
.25
2.5
1.5
4.5
1.5
6
ROUGH & READY
-31-60 - 37.0 C.F.S.
-67 - 31.27 "
PETERSBURG DITCH
12-30-73 - 27.0 "
MULLEN DITCH
10-7-64 - 61.71 C.F.S.
11-30-61 - 21.6 C.F.S.
12-30-63 - 5.4 "
CHERRY CREEK
RETURNED
DISTRICT No. 8
DISTRICT No. 2
WATER
WATER
DENVER LACOMBE SMITH DITCH
12-1-63 - 5.20 C.F.S. & 12-30-66 - 30 C.F.S. RETURN
SAND CREEK
RETURNED
PLANT 1900 - 300 C.F.S. RETURNED
DENVER-HUDSON - 11-28-07 - 300.0 C.F.S.
OBRIAN 3-9-08 - 600.0 C.F.S.
BURLINGTON DITCH 6-2-62 - 3.00 C.F.S.
BURLINGTON 11-20-85 - 350.0 "
4-1-84 - 26.4 "
ADAMS CITY
FULTON DITCH
3-1-65 - 79.70 C.F.S.
7-8-76 - 74.25 "
11-5-79 - 50.23 "
11-1-82 - 244.62 "
HENDERSON
BARR LAKE
11-20-85 - 8060 Ac.Ft.
1-14-09 - 21930 "
PROSPECT RESERVOIR
11-21-10 - 5970 Ac.Ft.
7-20-22 - 1690 "
HORSE CREEK RESERVOIR
3-17-11 - 16965 Ac.Ft.
7-20-22 - GAGE HT. FROM 48' TO 51'
OLDS RESERVOIR
1-28-18 - 534 Ac.Ft.
6-15-22 - 548 "
3.25
33

DITCHES


29.77 C.F.S.
5.95 "
12.18 "
63.30 "
BRIGHTON DITCH
12-1-63 – 22.22 C.F.S.
11-1-71 – 22.58 "
DRY CREEK
LUPTON BOTTOM DITCH
5-15-63-47.70 C.F.S.
9-15-73-92.87 "
ELWOOD DITCH
3-10-71-37.60 C.F.S
4-1-75-80.48 "
SIDE HILL DITCH
4-29-82-94.8 C.F.S.
TRS 5-1-66-22.0 "
ST. VRAIN CREEK
MUTUAL DITCH
BEEMAN-MEADOW
12-19-77-127 C.F.S. 5-3-66
ISLAND NO 2.-5-3-66-51.41 C.F.S.
4-10-76-7.41 "
6.42 C.F.S.
Only 4
JAY THOMAS DITCH
6-1-65-18.0 C.F.S.
3
4.25
.25
1.5
1
1
1.25
3
1.5
1.25
2
1.75
1.25
5.5
BRIGHTON
LUPTON SHORT LINE
7-6-82-72.0 C.F.S.
FT. LUPTON
PLATTEVILLE DITCH
7-1-62-47.88 C.F.S.
1-1-71- 5.25 "
10-15-73-94.25 "
EVANS NO 2. (PLATTE VALLEY CANAL)
10-5-71-177.07 C.F.S.
11-20-75-226.98 "
6-9-09-215.95 "
PLATTEVILLE
BUCKERS DITCH
7-8-79-121.87 C.F.S.
FARMER'S INDEPENDENT DITCH
11-20-65
11-1-79
313.0
C.F.S.
WESTERN DITCH
5-5-66-27.45 C.F.S.
8-10-71-71.12 "
1-26-94-86.43 "
MILTON LAKE
5-29-09-26773 AC. FT.
" " -(E)-16374 " "
33
63.5

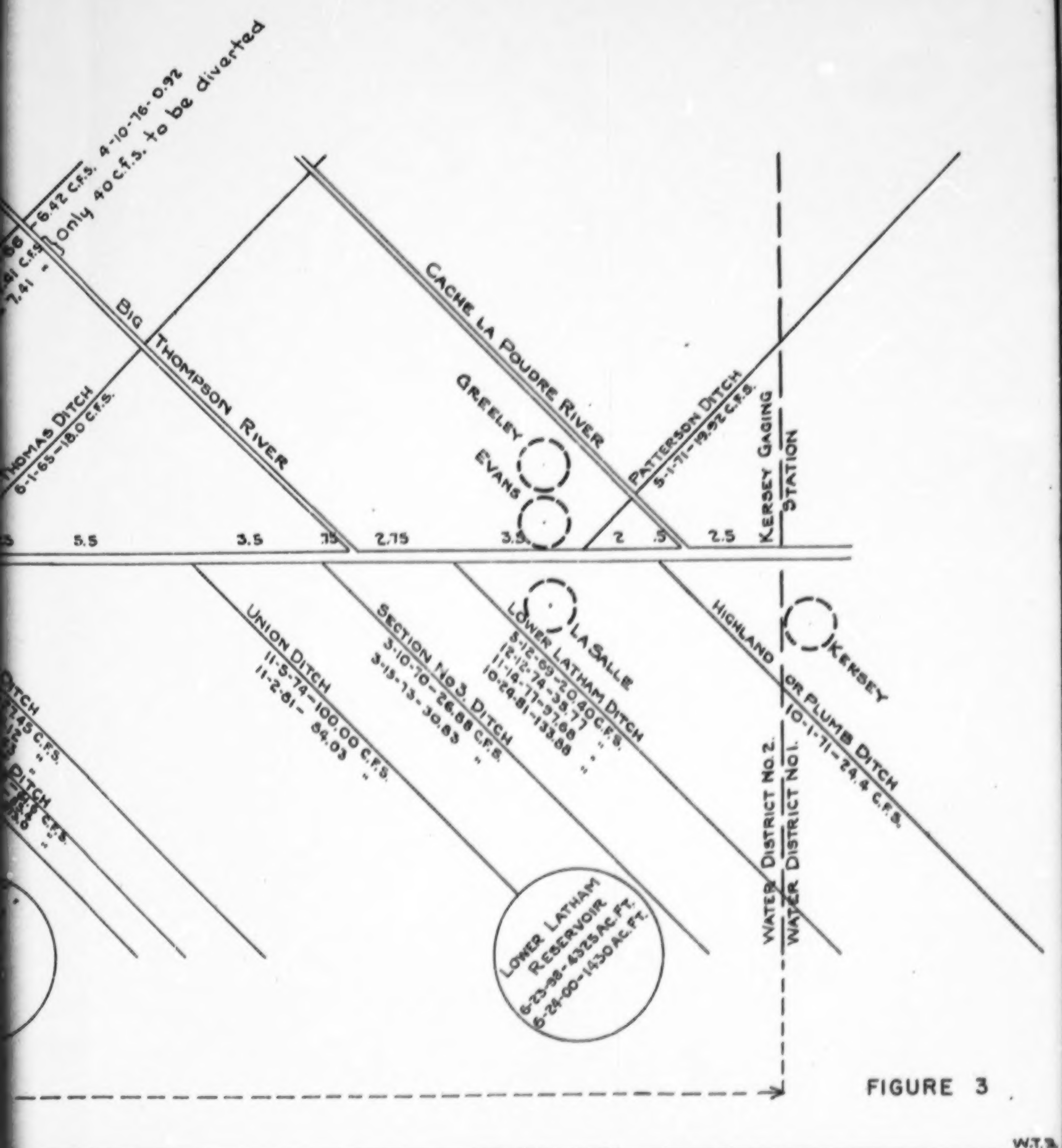
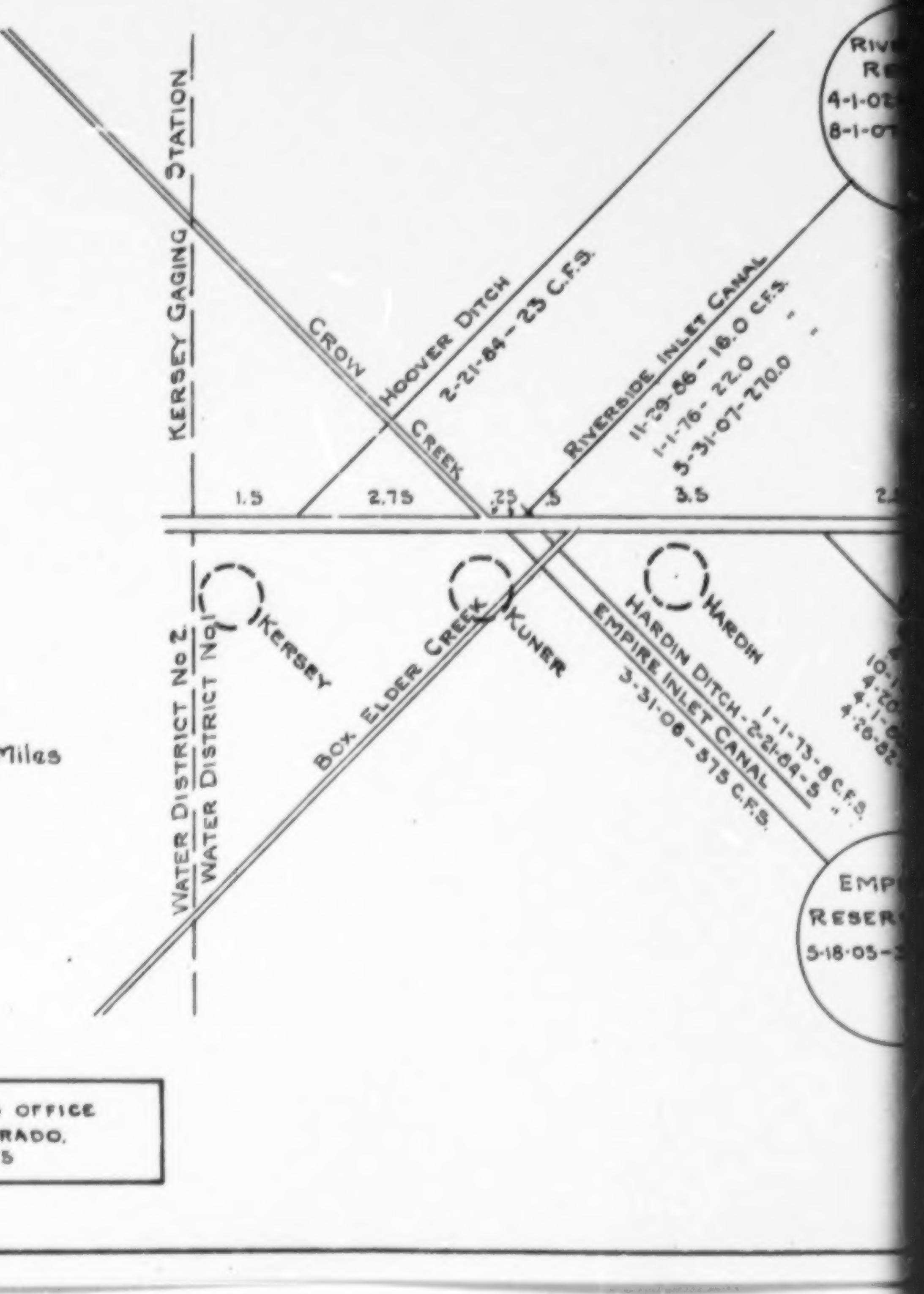

66
.41 C.F.S.
7.41 "
6.42 C.F.S. 4-10-76-0.92
Only 40 c.f.s. to be diverted
BIG THOMPSON RIVER
THOMAS DITCH
6-1-65-18.0 C.F.S.
CACHE LA POUDRE RIVER
GREELEY
EVANS
PATTERSON DITCH
5-1-71-19.92 C.F.S.
KERSEY GAGING STATION
5.5
3.5
.75
2.75
3.5
2
.5
2.5
DITCH
7.45 C.F.S.
DITCH
C.F.S.
UNION DITCH
11-5-74-100.00 C.F.S.
11-2-81- 84.03 "
SECTION NO 3. DITCH
3-10-70-26.88 C.F.S.
3-15-73-30.83 "
LOWER LATHAM DITCH
3-12-69-20.40 C.F.S.
12-12-74-35.77 "
11-14-77-37.68 "
10-24-81-133.88 "
LA SALLE
HIGHLAND OR PLUMB DITCH
10-1-71-24.4 C.F.S.
KERSEY
WATER DISTRICT NO 2.
WATER DISTRICT NO 1.
LOWER LATHAM RESERVOIR
6-23-98-4325 AC. FT.
6-24-00-1430 AC. FT.

FIGURE 3

W.T.B.


KERSEY GAGING STATION
CROW CREEK
HOOVER DITCH
2-21-84 – 23 C.F.S.
RIVERSIDE INLET CANAL
11-29-86 – 16.0 C.F.S.
1-1-76 – 22.0 "
5-31-07 – 270.0 "
1.5
2.75
.25
.5
3.5
KERSEY
KUNER
HARDIN
BOX ELDER CREEK
WATER DISTRICT No 2
WATER DISTRICT No 1
HARDIN DITCH – 2-21-84 – 5 "
1-1-73 – 8 C.F.S.
EMPIRE INLET CANAL
3-31-06 – 375 C.F.S.
4-1-02
8-1-07
5-18-05

Scale: 1 inch = 2 Miles

STATE ENGINEER'S OFFICE
DENVER, COLORADO.
APRIL 1925

SHOWING

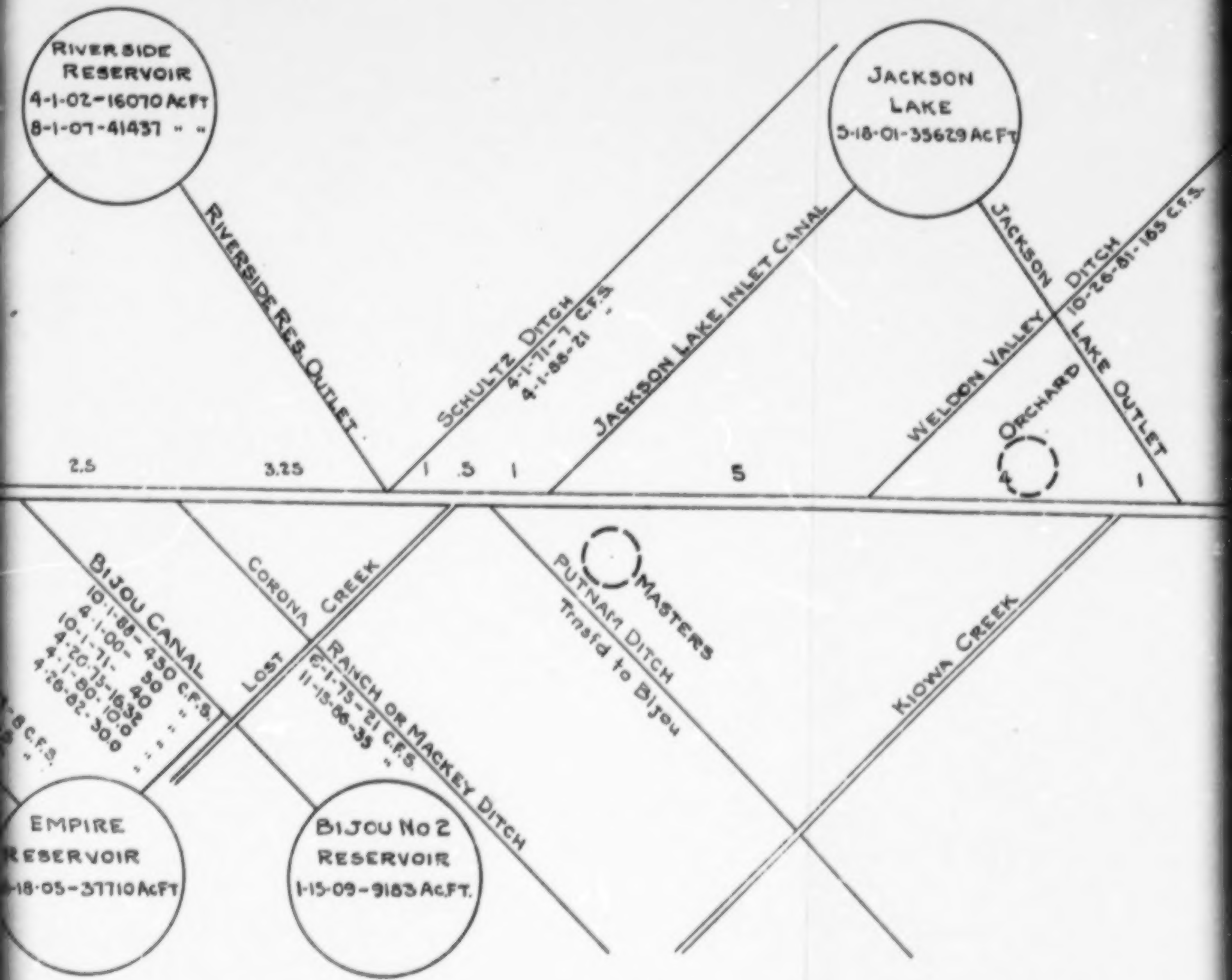
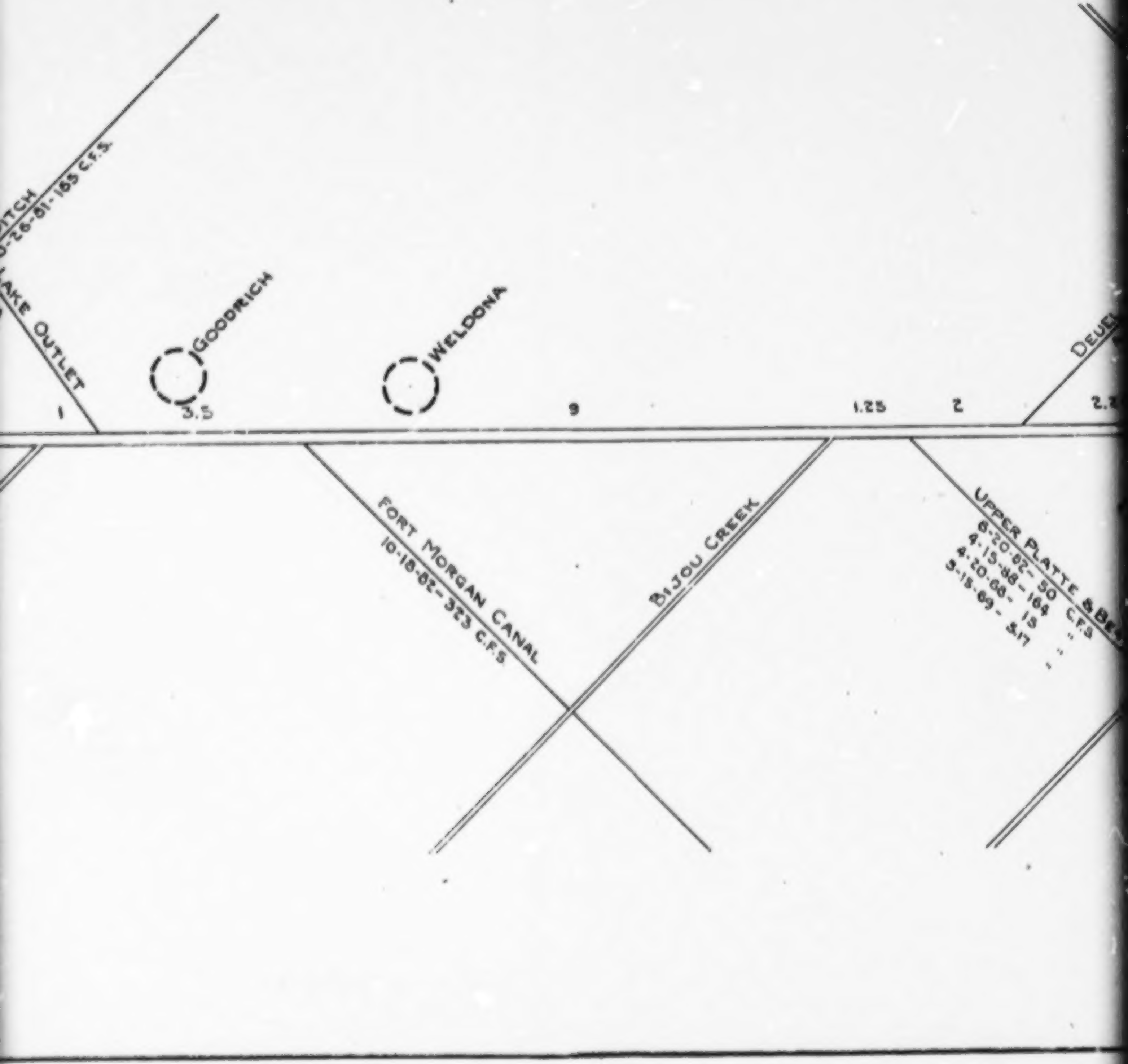
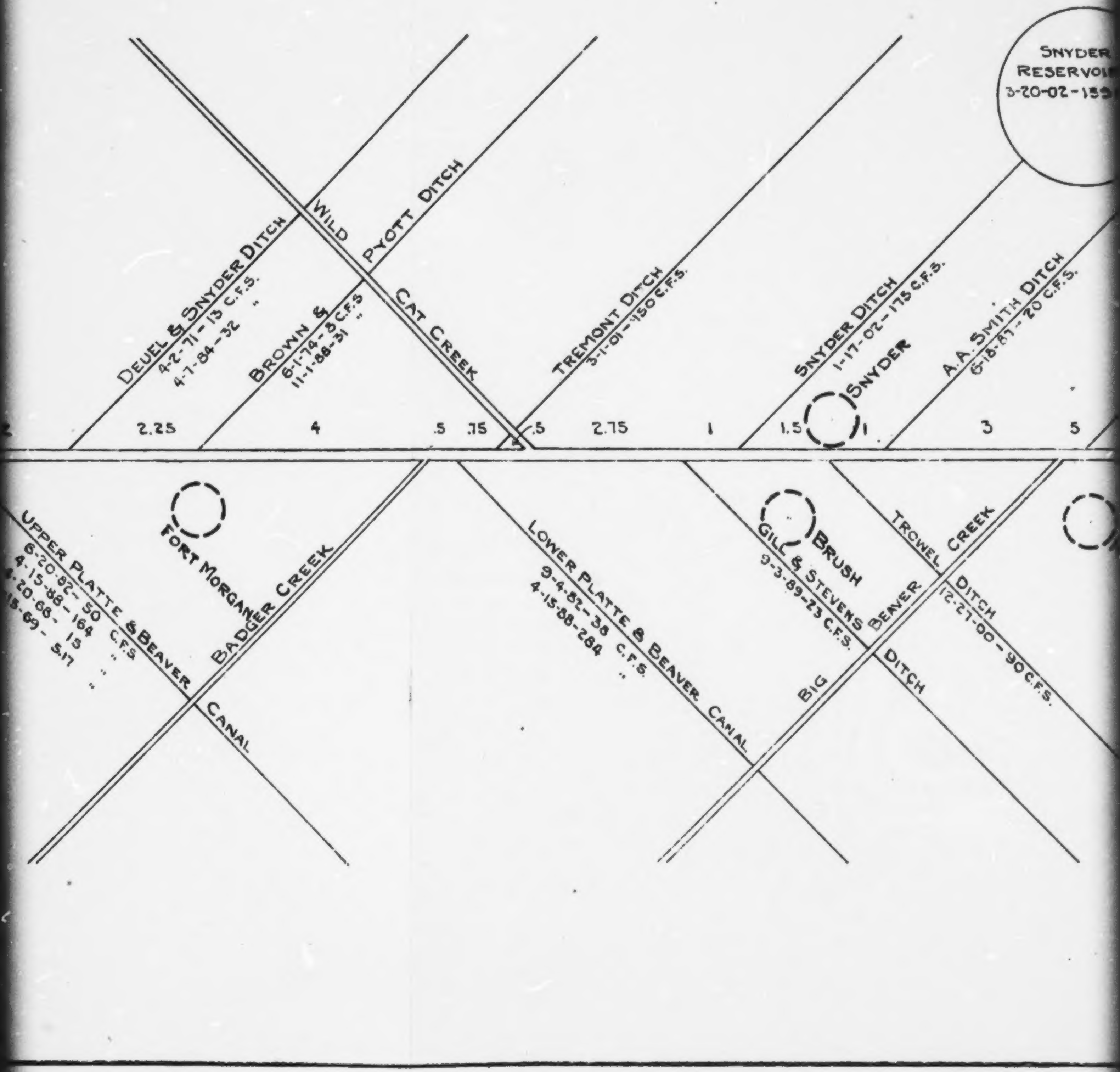

RIVERSIDE RESERVOIR
4-1-02-16070 Ac.Ft
8-1-07-41437 " "
RIVERSIDE RES. OUTLET
SCHULTZ DITCH
4-1-71-7 C.F.S.
4-1-88-21 "
JACKSON LAKE INLET CANAL
JACKSON LAKE
5-18-01-35629 Ac.Ft
JACKSON LAKE OUTLET
WELDON VALLEY DITCH
10-26-81-165 C.F.S.
ORCHARD
2.5
3.25
1
.5
1
5
4
1
BIJOU CANAL
10-1-88-450 C.F.S.
4-1-00-50 "
10-1-71-40 "
4-20-75-1632 "
4-1-80-10.0 "
4-26-82-30.0 "
-8 C.F.S.
"
CORONA
LOST CREEK
RANCH OR MACKEY DITCH
6-1-75-21 C.F.S.
11-15-86-35 "
MASTERS
PUTNAM DITCH
Trnsfd to Bijou
KIOWA CREEK
EMPIRE RESERVOIR
-18-05-37710 Ac.Ft
BIJOU No 2 RESERVOIR
1-15-09-9183 Ac.Ft.

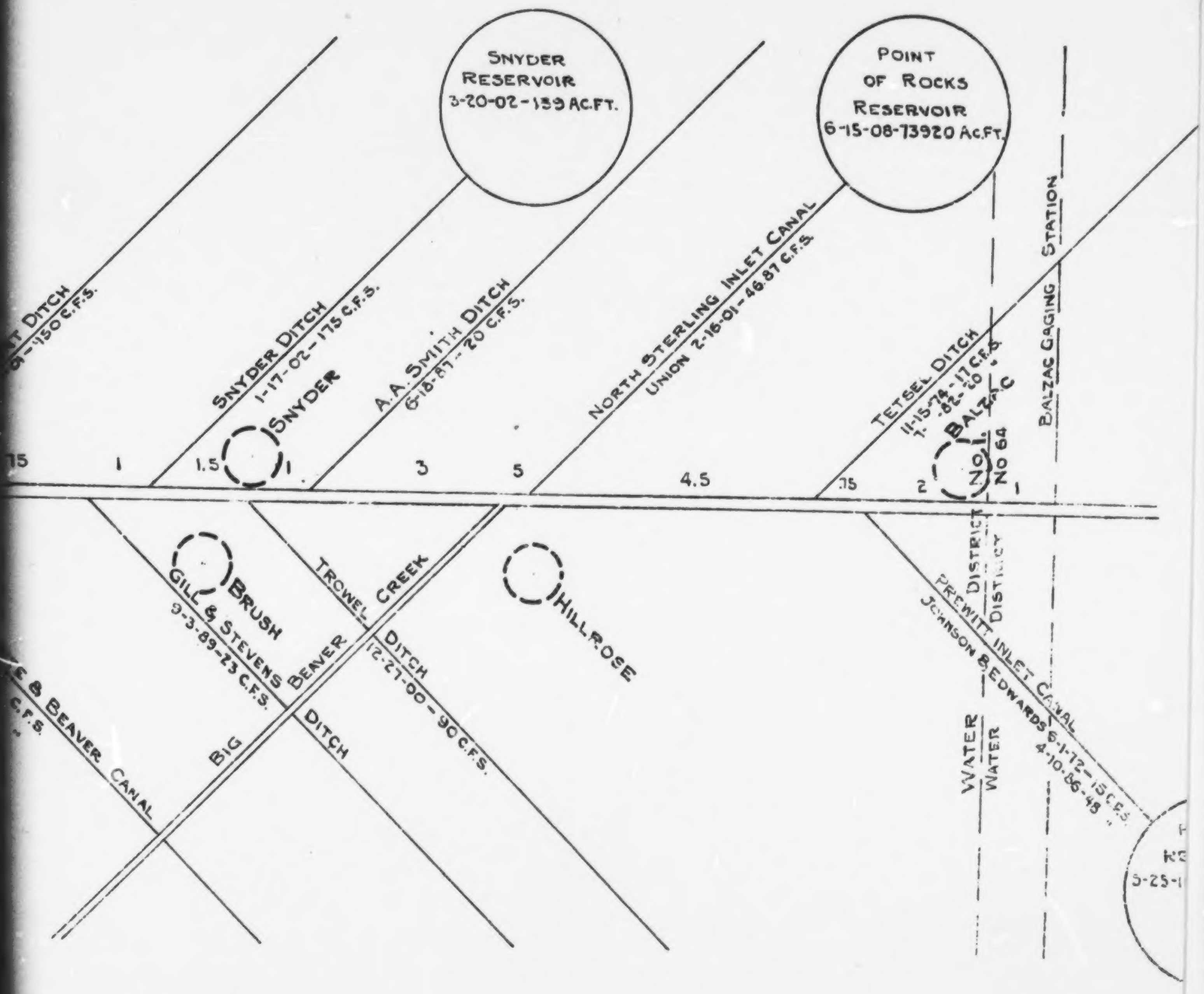
DIAGRAM
WING LOCATION OF AND DISTANCES BETWEEN DIT
FROM THE SOUTH PLATTE RIVER
KERSEY TO BALZAC


ITCH
0-26-81-165 C.F.S.
AKE OUTLET
1
GOODRICH
3.5
WELDONA
9
1.25
2
DEUEL
2.2
FORT MORGAN CANAL
10-18-82-323 C.F.S
BIJOU CREEK
UPPER PLATTE & BE
6-20-82-50 C.F.S
4-15-88-164 "
4-20-08-15 "
3-15-09-5.17 "

EEN DITCHES



Snyder
Reservoi
3-20-02-159
Deuel & Snyder Ditch
4-2-71-13 C.F.S.
4-7-84-32 "
Brown &
6-1-74-8 C.F.S
11-1-88-31 "
Wild
Cat Creek
Pyott Ditch
Tremont Ditch
3-1-01-150 C.F.S.
Snyder Ditch
1-17-02-175 C.F.S.
Snyder
A.A. Smith Ditch
6-18-87-20 C.F.S.
2
2.25
4
.5
.75
.5
2.75
1
1.5
1
3
5
Fort Morgan
Upper Platte & Beaver Canal
6-20-82-50 C.F.S
4-15-88-164 "
-20-68-15 "
18-69-5.17 "
Badger Creek
Lower Platte & Beaver Canal
9-4-82-38 C.F.S.
4-15-88-284 "
Brush
Gill & Stevens Ditch
9-3-89-23 C.F.S.
Big Beaver
Trowel Creek
Ditch
12-27-00-90 C.F.S.


SNYDER RESERVOIR 3-20-02-139 AC.FT.
POINT OF ROCKS RESERVOIR 6-15-08-73920 AC.FT.
T DITCH
-150 C.F.S.
SNYDER DITCH
1-17-02-175 C.F.S.
SNYDER
A.A. SMITH DITCH
6-18-87-20 C.F.S.
NORTH STERLING INLET CANAL
UNION 2-16-01-46.87 C.F.S.
TETSEL DITCH
11-15-74-17 C.F.S.
BALZAC
BALZAC GAGING STATION
.75
1
1.5
1
3
5
4.5
.75
2
1
WATER DISTRICT NO. 1
WATER DISTRICT NO 64
BRUSH
GILL & STEVENS
9-3-89-23 C.F.S.
TROWEL CREEK
DITCH
12-27-00-90 C.F.S.
HILLROSE
BIG BEAVER DITCH
E & BEAVER CANAL
C.F.S.
PREWITT INLET CANAL
JOHNSON & EDWARDS 6-1-72-15 C.F.S.
4-10-86-48
5-25-1

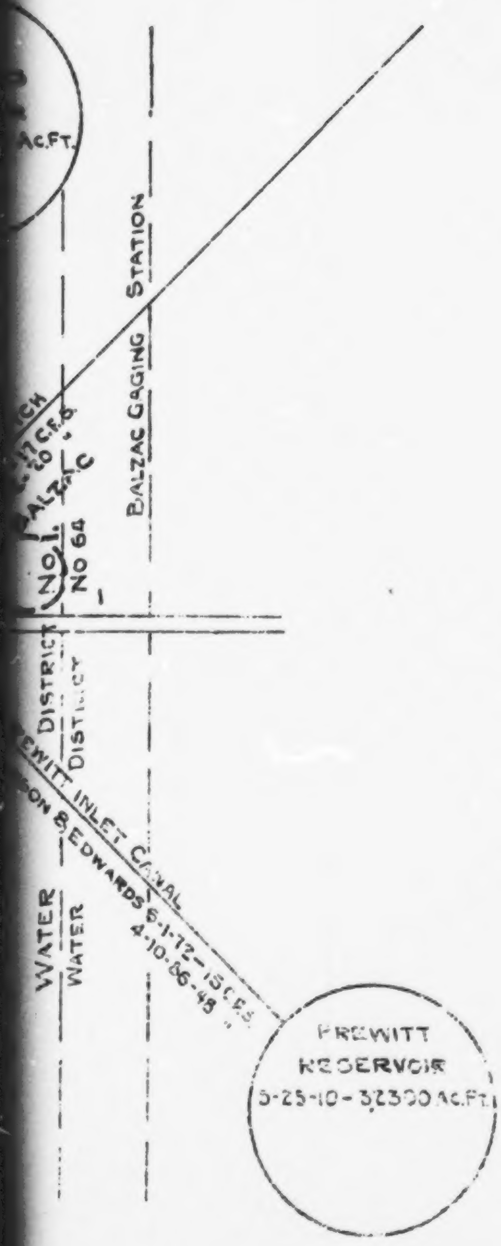
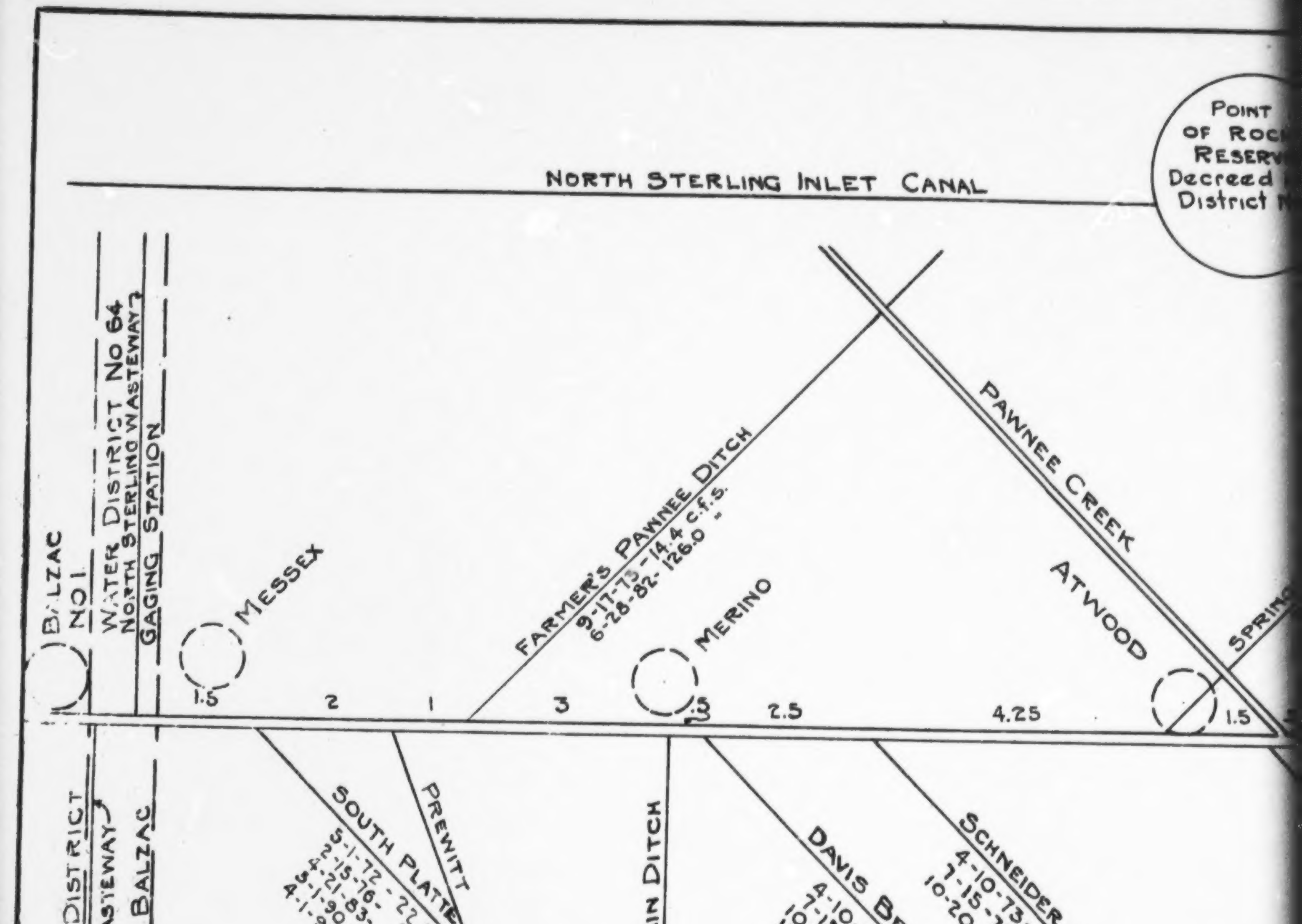
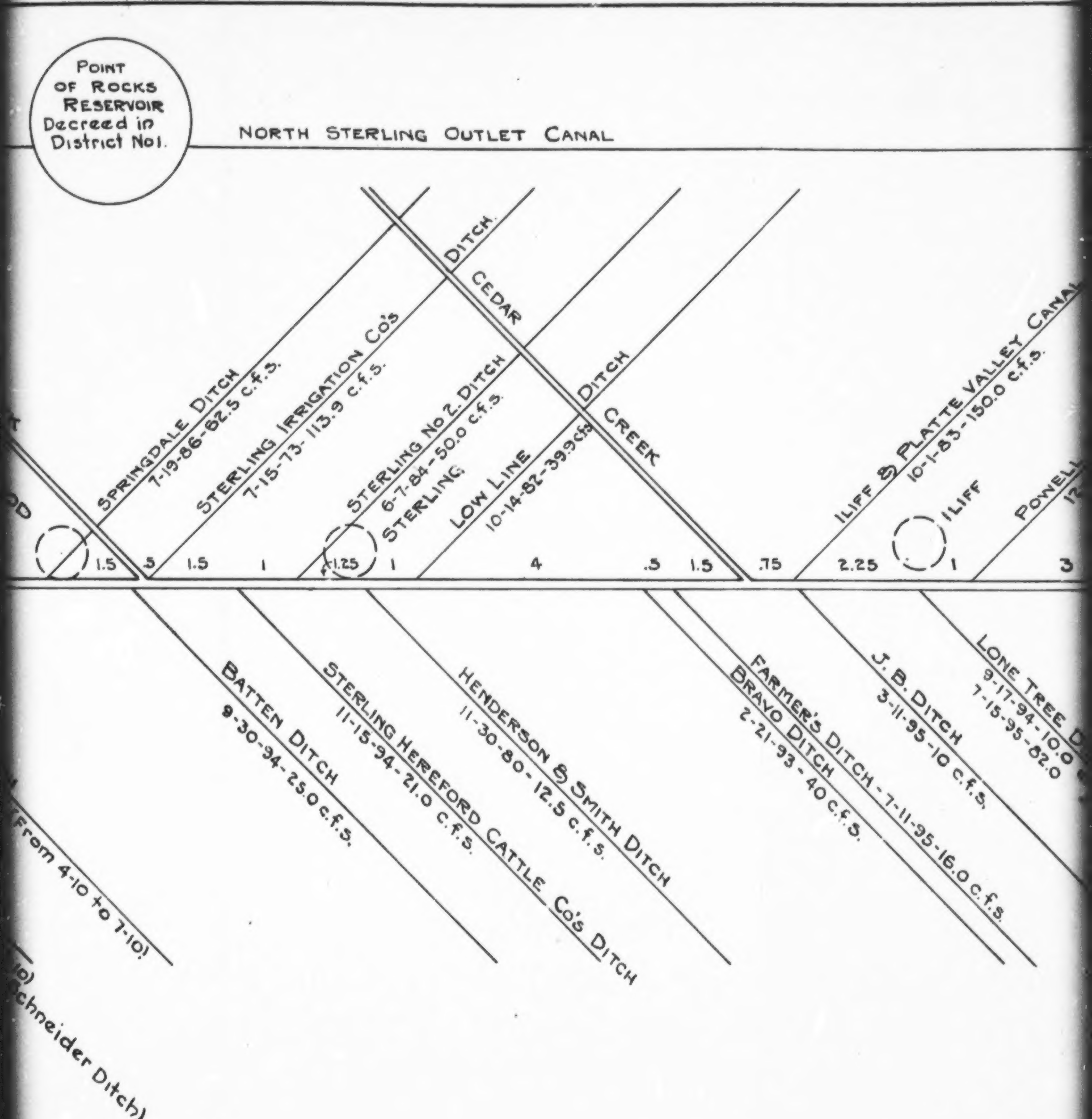
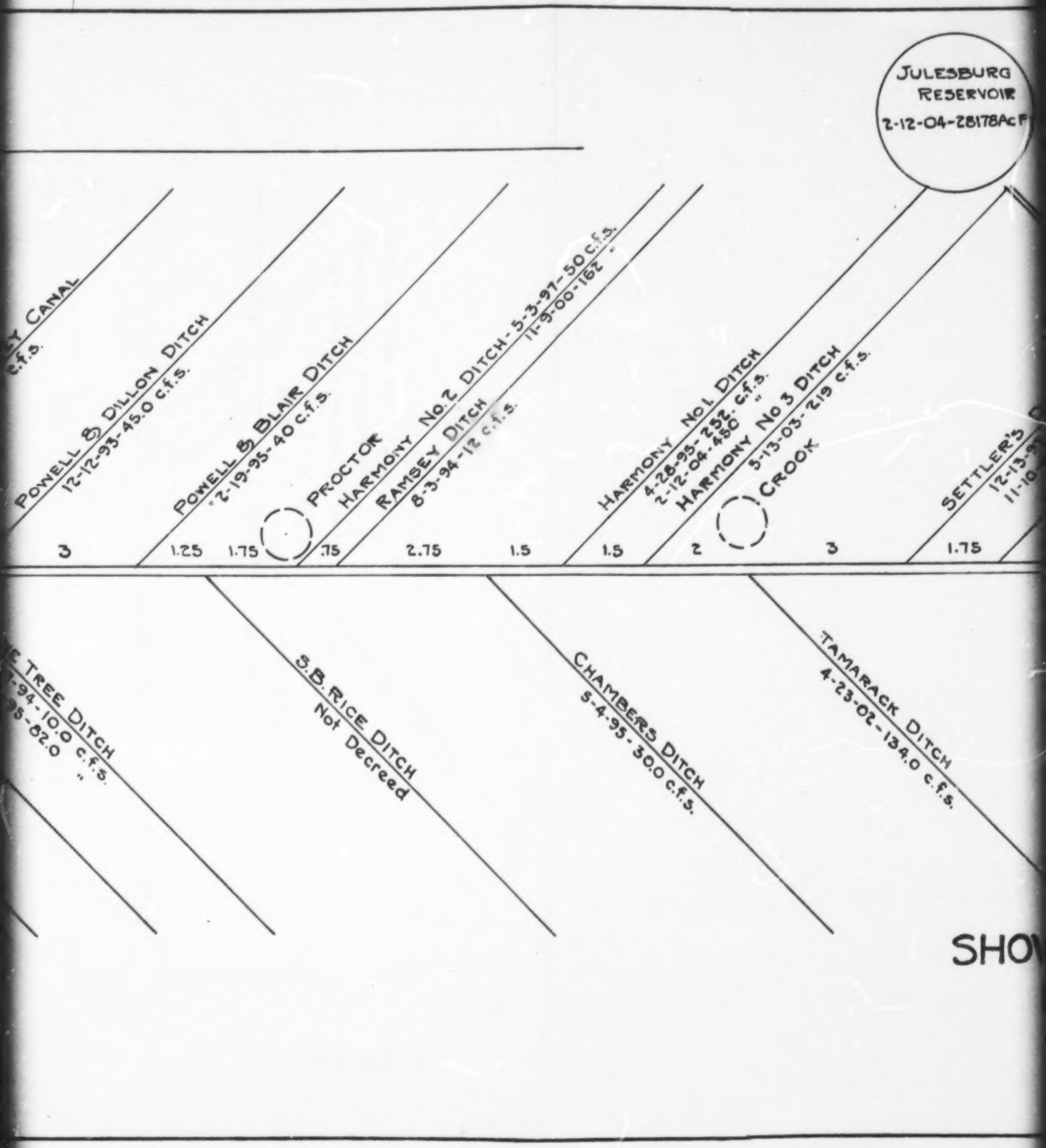
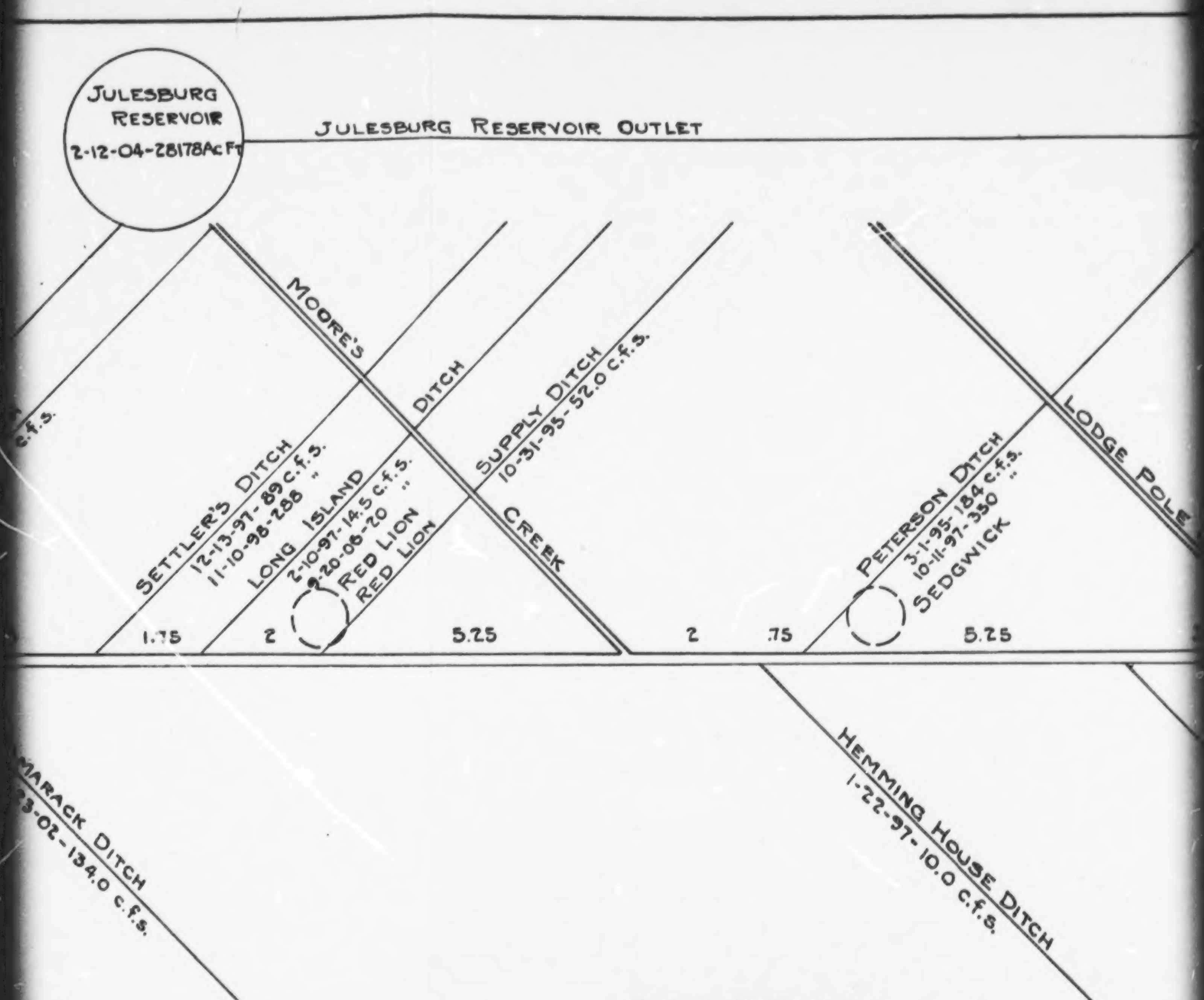

Ac.Ft.
BALZAC GAGING STATION
ICH
No.1
No 64
DISTRICT
DISTRICT
WATER
WATER
EWITT INLET CANAL
ON & EDWARDS 8-1-72-15 C.F.S.
4-10-86-48
PREWITT RESERVOIR
5-25-10-32,300 Ac.Ft.

FIGURE 4


NORTH STERLING INLET CANAL
POINT
OF ROC
RESERV
Decreed
District N
BALZAC
NO 1.
WATER DISTRICT NO 64
NORTH STERLING WASTEWAY
GAGING STATION
MESSEX
FARMER'S PAWNEE DITCH
9-17-73 - 14.4 c.f.s.
6-28-82 - 126.0 "
MERINO
PAWNEE CREEK
ATWOOD
SPRIN
1.5
2
1
3
.5
2.5
4.25
1.5
WATER DISTRICT
PREWITT WASTEWAY
BALZAC
SOUTH PLATTE DITCH
5-1-72 - 22.5 c.f.s.
2-15-76 - 7.5 "
4-21-83 - 20.0 "
3-1-90 - 37.5 "
4-1-96 - 50.0 "
PREWITT OUTLET
PREWITT DRAIN DITCH
DAVIS BROS. DITCH
4-10-74 - 2.0 c.f.s. (From 4-10 to 7-10)
7-15-75 - 6.9 "
10-20-80 - 6.0 "
1-1-90 - 30.0 "
5-20-94 - 20.0 "
5-25-03 - 102.0
(May be run in Schneider Ditch)
SCHNEIDER DITCH
4-10-73 - 11.0 c.f.s. (From 4-10 to 7-10)
7-15-75 - 18.1 "
10-20-80 - 15.93 "
PREWITT
RESERVOIR
Decreed in
District No 1.
PREWITT INLET CANAL


Point of Rocks Reservoir Decreed in District No1.
North Sterling Outlet Canal
K
OD
Springdale Ditch
7-19-86-62.5 c.f.s.
Sterling Irrigation Co's
7-15-73-113.9 c.f.s.
Ditch.
Cedar
Creek
Ditch
Sterling No 2. Ditch
6-7-84-50.0 c.f.s.
Sterling
Low Line
10-14-82-39.9 cfs
Iliff & Platte Valley Canal
10-1-83-150.0 c.f.s.
Iliff
Powell
12
1.5
.5
1.5
1
1.25
1
4
.5
1.5
.75
2.25
1
3
Batten Ditch
9-30-94-25.0 c.f.s.
Sterling Hereford Cattle Co's Ditch
11-15-94-21.0 c.f.s.
Henderson & Smith Ditch
11-30-80-12.5 c.f.s.
Bravo Ditch
2-21-93-40 c.f.s.
Farmer's Ditch-7-11-95-16.0 c.f.s.
J. B. Ditch
3-11-95-10 c.f.s.
Lone Tree D
9-17-94-10.0
7-15-95-82.0
(From 4-10 to 7-10)
10)
Schneider Ditch)

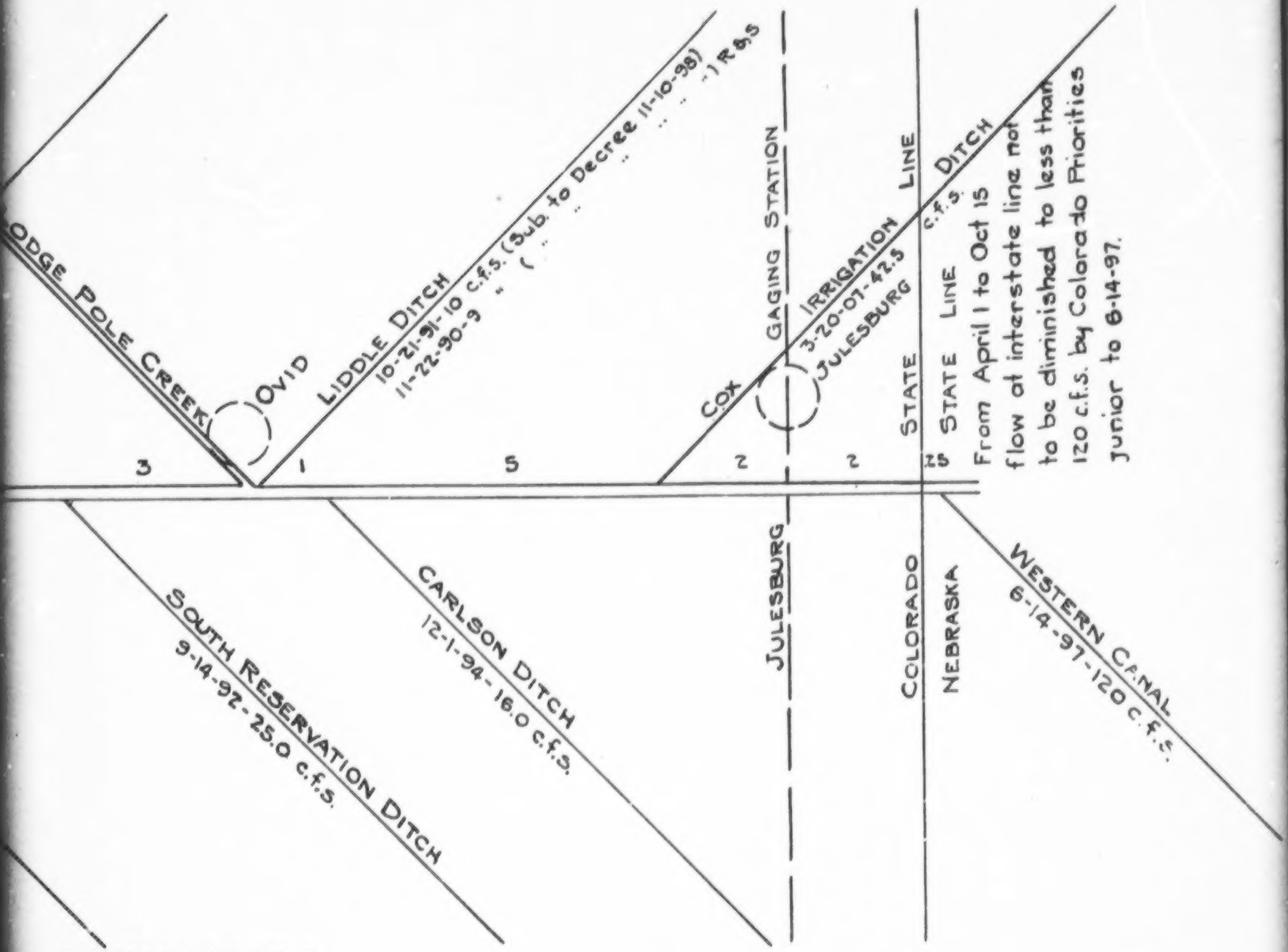

Y CANAL
c.f.s.
POWELL & DILLON DITCH
12-12-93-45.0 c.f.s.
POWELL & BLAIR DITCH
2-19-95-40 c.f.s.
PROCTOR
HARMONY No.2 DITCH-5-3-97-50 c.f.s.
11-9-00-162 "
RAMSEY DITCH
8-3-94-12 c.f.s.
HARMONY No.1 DITCH
4-28-95-252 c.f.s.
2-12-04-450 "
HARMONY No 3 DITCH
5-13-03-219 c.f.s.
CROOK
SETTLER'S D
12-13-9
11-10
JULESBURG
RESERVOIR
2-12-04-28178Ac F
3
1.25
1.75
.75
2.75
1.5
1.5
2
3
1.75
E TREE DITCH
7-94-10.0 c.f.s.
95-82.0 "
S.B. RICE DITCH
Not Decreed
CHAMBERS DITCH
5-4-95-30.0 c.f.s.
TAMARACK DITCH
4-23-02-134.0 c.f.s.
SHOW


JULESBURG RESERVOIR
2-12-04-28178 Ac Ft
JULESBURG RESERVOIR OUTLET
c.f.s.
MOORE'S
DITCH
CREEK
SETTLER'S DITCH
12-13-97-89 c.f.s.
11-10-98-288 "
LONG ISLAND
2-10-97-14.5 c.f.s.
9-20-06-20 "
RED LION
RED LION
SUPPLY DITCH
10-31-95-52.0 c.f.s.
PETERSON DITCH
3-1-95-184 c.f.s.
10-11-97-350 "
SEDGWICK
LODGE POLE
1.75
2
5.25
2
.75
5.25
MARACK DITCH
23-02-134.0 c.f.s.
HEMMING HOUSE DITCH
1-22-97-10.0 c.f.s.

DIAGRAM

SHOWING LOCATION OF AND DISTANCES BET
DITCHES FROM THE SOUTH PLATTE RI
BALZAC TO JULESBURG

SCALE: 1" = 2 MILES.


LODGE POLE CREEK
OVID
LIDDLE DITCH
10-21-91-10 c.f.s. (Sub. to Decree 11-10-98)
11-22-90-9 " (" " ") R 8.5
COX
GAGING STATION
IRRIGATION
3-20-07-42.5
JULESBURG
STATE
LINE
c.f.s.
DITCH
STATE LINE
3
1
5
2
2
25
SOUTH RESERVATION DITCH
9-14-92-25.0 c.f.s.
CARLSON DITCH
12-1-94-16.0 c.f.s.
JULESBURG
COLORADO
NEBRASKA
WESTERN CANAL
6-14-97-120 c.f.s.

From April 1 to Oct 15
flow at interstate line not
to be diminished to less than
120 c.f.s. by Colorado Priorities
junior to 6-14-97.

S BETWEEN
TE RIVER

FIGURE 5

W.T.B.

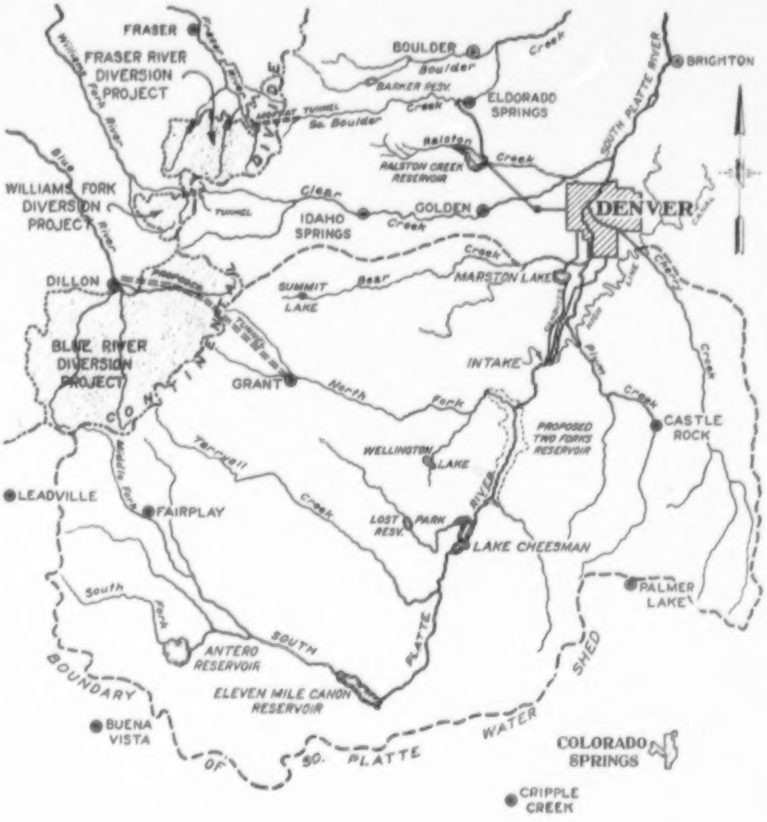
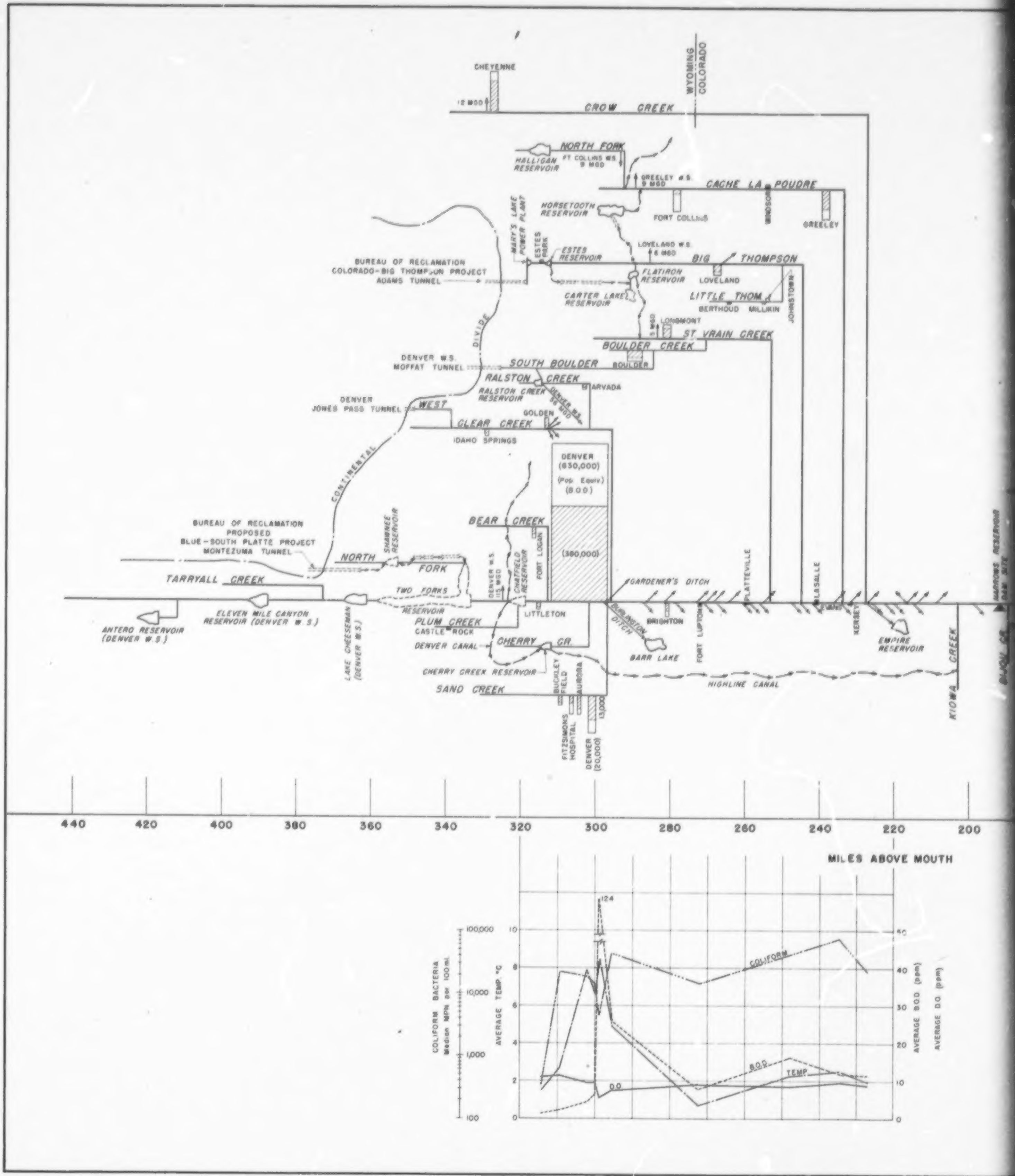

FRASER
FRASER RIVER DIVERSION PROJECT
Williams Fork River
MOFFAT TUNNEL
DIVIDE
BOULDER
Boulder Creek
BARKER RESV.
So. Boulder Creek
ELDORADO SPRINGS
BRIGHTON
SOUTH PLATTE RIVER
Ralston Creek
RALSTON CREEK RESERVOIR
WILLIAMS FORK DIVERSION PROJECT
Blue River
TUNNEL
Clear Creek
IDAHO SPRINGS
GOLDEN
DENVER
CANAL
DILLON
SUMMIT LAKE
Bear Creek
MARSTON LAKE
Cherry Creek
HIGH LINE
CONDUITS
BLUE RIVER DIVERSION PROJECT
TUNNEL
CONTINENTAL
INTAKE
GRANT
North Fork
Plum Creek
CASTLE ROCK
PROPOSED TWO FORKS RESERVOIR
WELLINGTON LAKE
Creek
LEADVILLE
Middle Fork
FAIRPLAY
Tarryall Creek
LOST PARK RESV.
RIVER
LAKE CHEESMAN
PALMER LAKE
South Fork
ANTERO RESERVOIR
SOUTH PLATTE
ELEVEN MILE CANON RESERVOIR
BOUNDARY OF SO. PLATTE WATER SHED
BUENA VISTA
COLORADO SPRINGS
CRIPPLE CREEK

FIGURE 6

GENERAL MAP OF ENTIRE DENVER WATER SYSTEM
PRESENT & PROPOSED

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
APRIL 1949


CHEYENNE
12 MGD
CROW CREEK
WYOMING
COLORADO
NORTH FORK
HALLIGAN RESERVOIR
FT COLLINS W.S. 9 MGD
GREELEY W.S. 9 MGD
CACHE LA POUDRE
HORSETOOTH RESERVOIR
FORT COLLINS
WINDSOR
GREELEY
MARY'S LAKE POWER PLANT
ESTES PARK
ESTES RESERVOIR
LOVELAND W.S. 6 MGD
BIG THOMPSON
BUREAU OF RECLAMATION
COLORADO-BIG THOMPSON PROJECT
ADAMS TUNNEL
FLATIRON RESERVOIR
LOVELAND
CARTER LAKE RESERVOIR
LITTLE THOM
BERTHOUD
MILLIKIN
JOHNSTOWN
5 MGD
LONGMONT
ST VRAIN CREEK
BOULDER CREEK
BOULDER
DENVER W.S.
MOFFAT TUNNEL
SOUTH BOULDER
DIVIDE
RALSTON CREEK
RALSTON CREEK RESERVOIR
DENVER W.S. 56 MGD
ARVADA
DENVER
JONES PASS TUNNEL
WEST
CLEAR CREEK
GOLDEN
IDAHO SPRINGS
DENVER (630,000) (Pop Equiv) (B.O.D)
(380,000)
CONTINENTAL
BUREAU OF RECLAMATION
PROPOSED
BLUE-SOUTH PLATTE PROJECT
MONTEZUMA TUNNEL
SHAWNEE RESERVOIR
BEAR CREEK
NORTH FORK
TARRYALL CREEK
DENVER W.S. 115 MGD
CHATFIELD RESERVOIR
FORT LOGAN
TWO FORKS RESERVOIR
GARDENER'S DITCH
PLATTEVILLE
LASALLE
EVANS
KERSEY
NARROWS RESERVOIR DAM SITE
ANTERO RESERVOIR (DENVER W.S.)
ELEVEN MILE CANYON RESERVOIR (DENVER W.S.)
LAKE CHEESEMAN (DENVER W.S.)
LITTLETON
PLUM CREEK
CASTLE ROCK
BURLINGTON DITCH
BRIGHTON
FORT LUPTON
EMPIRE RESERVOIR
DENVER CANAL
CHERRY CR.
CHERRY CREEK RESERVOIR
BARR LAKE
HIGHLINE CANAL
KIOWA CREEK
BIJOU CR.
SAND CREEK
BUCKLEY FIELD
AURORA
FITZSIMONS HOSPITAL
DENVER (20,000)
13,000
440
420
400
380
360
340
320
300
280
260
240
220
200
MILES ABOVE MOUTH
COLIFORM BACTERIA Median MPN per 100 ml.
100,000
10,000
1,000
100
AVERAGE TEMP. °C
10
8
6
4
2
0
124
COLIFORM
B.O.D
TEMP
D.O
AVERAGE B.O.D. (ppm)
AVERAGE D.O. (ppm)
50
40
30
20
10
0

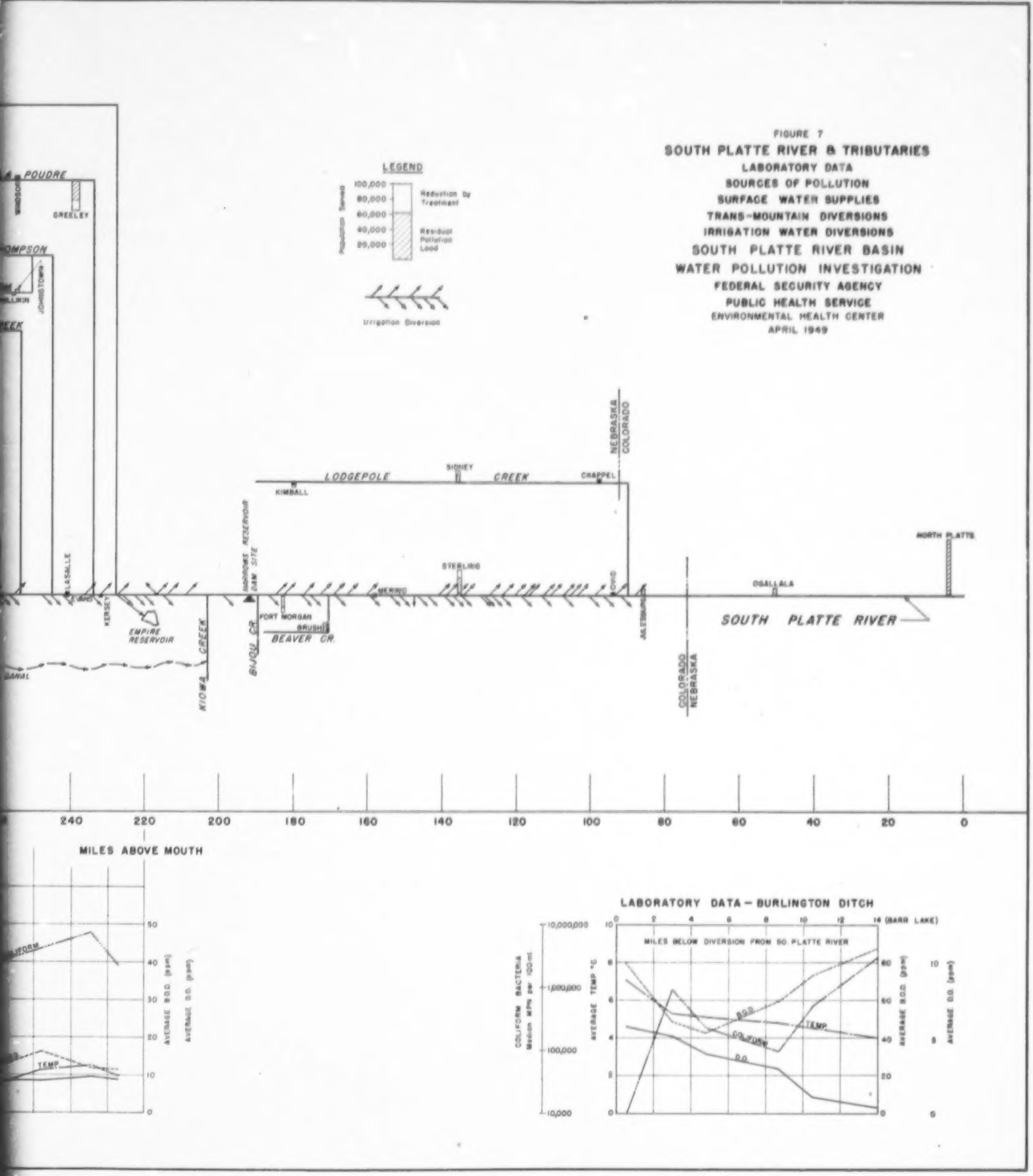
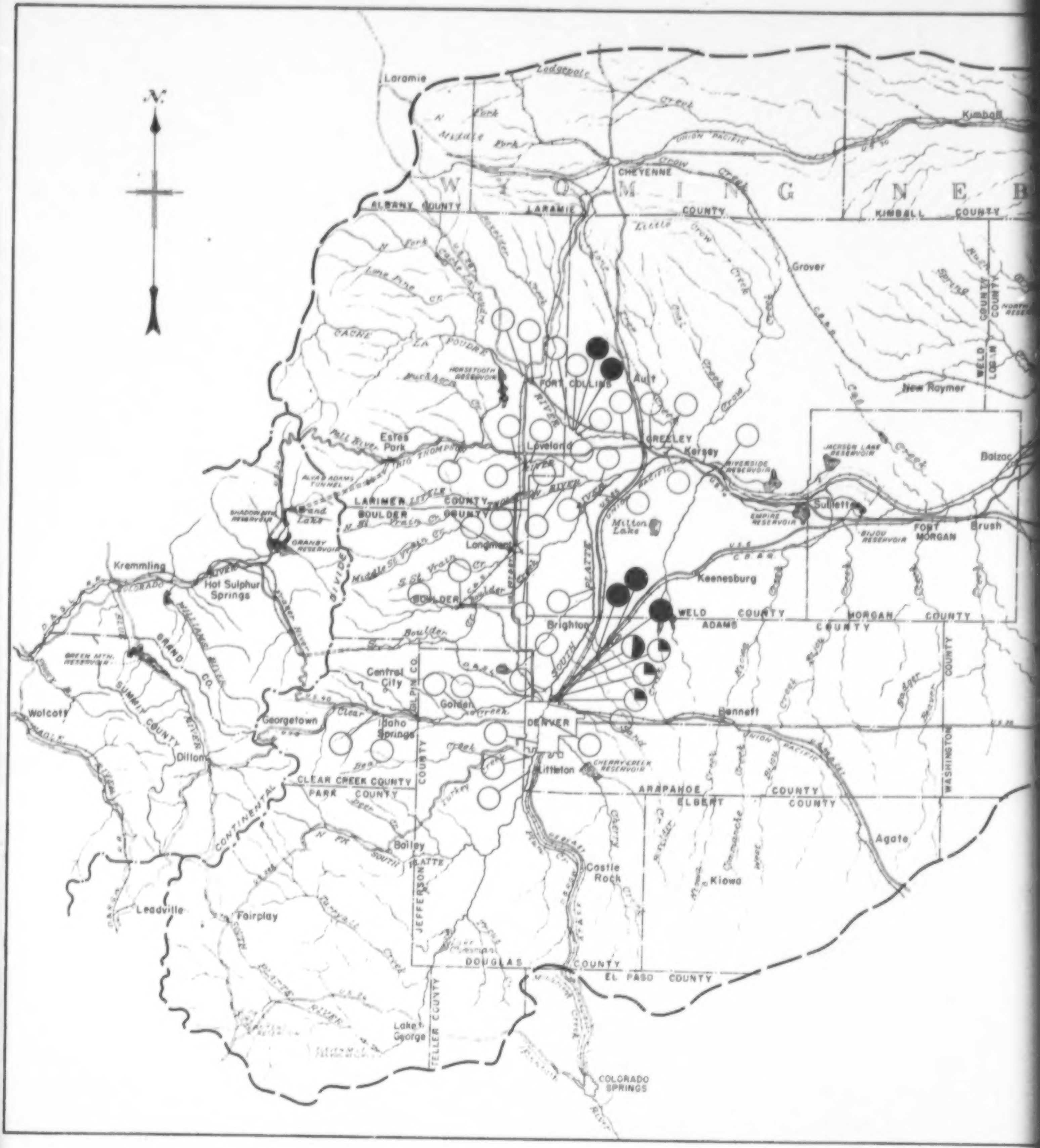

LEGEND
100,000
80,000
60,000
40,000
20,000
Population Served
Reduction by Treatment
Residual Pollution Load
Irrigation Diversion
POUDRE
WINDSOR
GREELEY
JOHNSTOWN
LASALLE
EVANS
KERSEY
EMPIRE RESERVOIR
KIOWA CREEK
NARROWS RESERVOIR DAM SITE
BIJOU CR.
FORT MORGAN
BRUSH
BEAVER CR.
LODGEPOLE
CREEK
KIMBALL
SIDNEY
CHAPPEL
NEBRASKA
COLORADO
MERINO
STERLING
OVID
JULESBURG
COLORADO
NEBRASKA
OGALLALA
NORTH PLATTE
SOUTH PLATTE RIVER
240
220
200
180
160
140
120
100
80
60
40
20
0
MILES ABOVE MOUTH
50
40
30
20
10
0
AVERAGE B.O.D. (ppm)
AVERAGE D.O. (ppm)
TEMP.
LABORATORY DATA – BURLINGTON DITCH
MILES BELOW DIVERSION FROM SO. PLATTE RIVER
0
2
4
6
8
10
12
14 (BARR LAKE)
COLIFORM BACTERIA Median MPN per 100 ml
10,000,000
1,000,000
100,000
10,000
AVERAGE TEMP °C
10
8
6
4
2
0
AVERAGE B.O.D. (ppm)
80
60
40
20
0
AVERAGE D.O. (ppm)
10
5
0
B.O.D.
TEMP.
COLIFORM
D.O.

FIGURE 7
SOUTH PLATTE RIVER & TRIBUTARIES
LABORATORY DATA
SOURCES OF POLLUTION
SURFACE WATER SUPPLIES
TRANS-MOUNTAIN DIVERSIONS
IRRIGATION WATER DIVERSIONS
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
APRIL 1949


N.
Laramie
Lodgepole
Creek
N. Fork
Arsdale Fork
UNION PACIFIC
CHEYENNE
Crow Creek
Kimball
U.S. 30
W Y O M I N G
N E B
ALBANY COUNTY
LARAMIE
COUNTY
KIMBALL COUNTY
Little Crow Creek
Grover
N. Fork
Lone Pine Cr.
CACHE LA POUDRE
HORSETOOTH RESERVOIR
Buckhorn Cr.
FORT COLLINS
Ault
New Raymer
WELD COUNTY
LOGAN COUNTY
GREELEY
Kersey
Estes Park
Fall River
BIG THOMPSON
Loveland
RIVERSIDE RESERVOIR
JACKSON LAKE RESERVOIR
Balzac
ALVA B. ADAMS TUNNEL
LARIMER COUNTY
BOULDER COUNTY
LITTLE THOMPSON RIVER
SHADOW MTN. RESERVOIR
Grand Lake
GRANBY RESERVOIR
EMPIRE RESERVOIR
Sullivan
FORT MORGAN
Brush
BIJOU RESERVOIR
Milton Lake
N. St. Vrain Cr.
Longmont
Middle St. Vrain Cr.
S. St. Vrain Cr.
Kremmling
COLORADO
Hot Sulphur Springs
DIVIDE
Keenesburg
BOULDER
Brighton
SOUTH PLATTE RIVER
WELD COUNTY
ADAMS COUNTY
MORGAN COUNTY
WILLIAMS RIVER
GRAND CO.
GREEN MTN. RESERVOIR
SUMMIT COUNTY
BLUE RIVER
Central City
GILPIN CO.
Golden
Clear Creek
Georgetown
Idaho Springs
DENVER
Bennett
Wolcott
EAGLE
Dillon
CLEAR CREEK COUNTY
PARK COUNTY
JEFFERSON COUNTY
Littleton
CHERRY CREEK RESERVOIR
ARAPAHOE COUNTY
ELBERT COUNTY
WASHINGTON COUNTY
UNION PACIFIC
Kiowa
Castle Rock
Agate
Bailey
N. FK. SOUTH PLATTE
Leadville
Fairplay
CONTINENTAL
Turkey Creek
Bear Cr.
Cherry Cr.
DOUGLAS COUNTY
EL PASO COUNTY
TELLER COUNTY
Lake George
COLORADO SPRINGS
SOUTH PLATTE RIVER

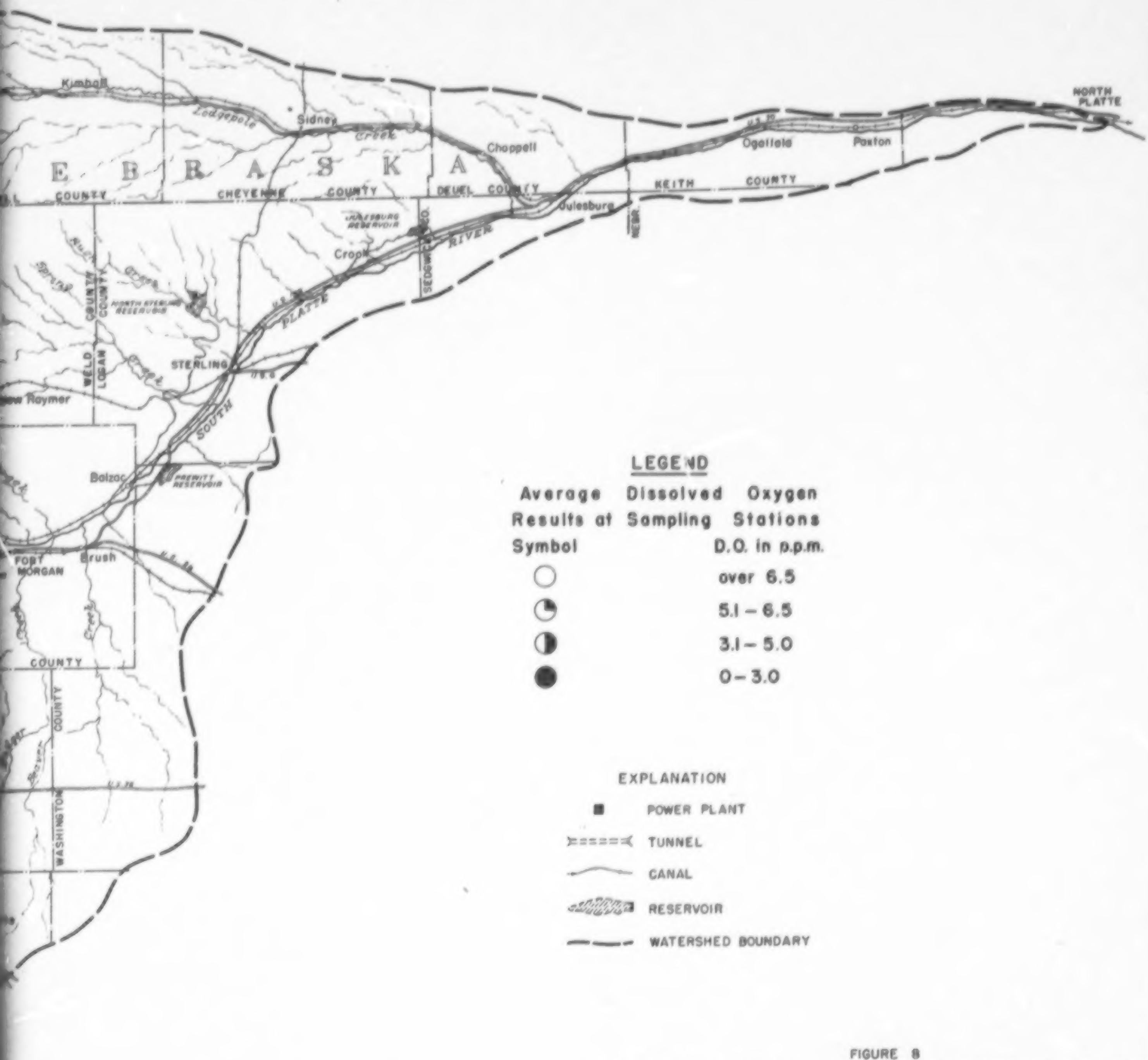
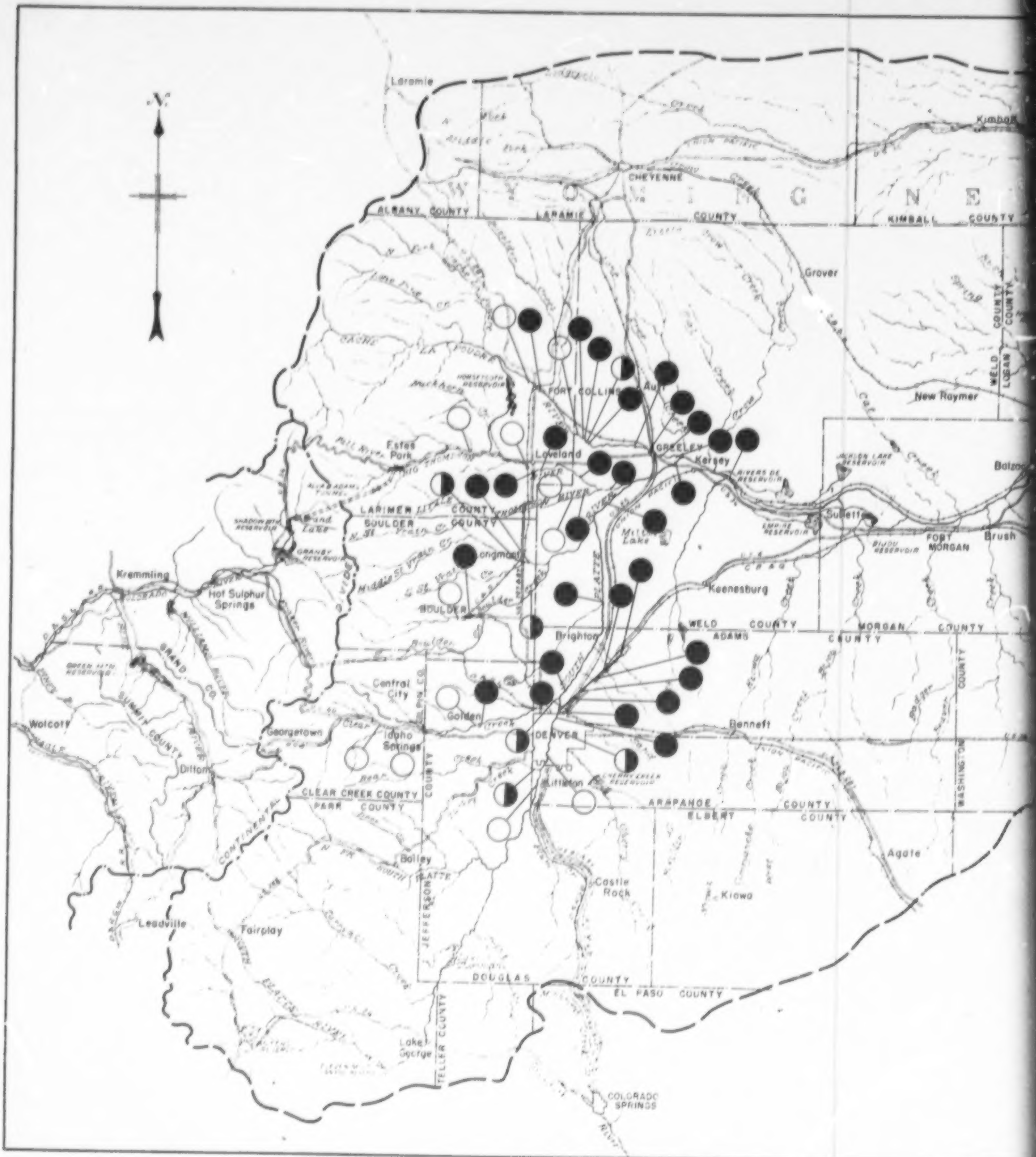

Kimball
Lodgepole
Sidney
Creek
Chappell
NORTH PLATTE
Ogallala
Paxton
U.S. 30
N E B R A S K A
COUNTY
CHEYENNE COUNTY
DEUEL COUNTY
KEITH COUNTY
Julesburg
NEBR.
JULESBURG RESERVOIR
SEDGWICK CO.
Crook
RIVER
PLATTE
SOUTH
U.S. 6
Spring
Creek
NORTH STERLING RESERVOIR
WELD COUNTY
LOGAN COUNTY
STERLING
Raymer
Balzac
PREWITT RESERVOIR
FORT MORGAN
Brush
U.S. 34
COUNTY
WASHINGTON COUNTY
Beaver Creek
U.S. 36
LEGEND
Average Dissolved Oxygen
Results at Sampling Stations
Symbol
D.O. in p.p.m.
○ over 6.5
◔ 5.1 – 6.5
◑ 3.1 – 5.0
● 0 – 3.0
EXPLANATION
■ POWER PLANT
TUNNEL
CANAL
RESERVOIR
WATERSHED BOUNDARY
8 0 8 16 24 32 40
SCALE OF MILES

FIGURE 8

DISSOLVED OXYGEN RESULTS AT SAMPLING STATIONS
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
APRIL 1949


N
Laramie
Cheyenne
WYOMING
NE
ALBANY COUNTY
LARAMIE COUNTY
KIMBALL COUNTY
Kimball
Grover
New Raymer
WELD COUNTY
LOGAN COUNTY
CACHE LA POUDRE
HORSETOOTH RESERVOIR
FORT COLLINS
Ault
GREELEY
Kersey
Estes Park
Loveland
BIG THOMPSON
LARIMER COUNTY
BOULDER COUNTY
Grand Lake
SHADOW MTN. RESERVOIR
GRANBY RESERVOIR
Longmont
Milton Lake
JACKSON LAKE RESERVOIR
EMPIRE RESERVOIR
Sublette
BIJOU RESERVOIR
FORT MORGAN
Brush
Keenesburg
Kremmling
Hot Sulphur Springs
GREEN MTN. RESERVOIR
BOULDER
Brighton
WELD COUNTY
ADAMS COUNTY
MORGAN COUNTY
WASHINGTON COUNTY
Central City
Golden
Wolcott
Georgetown
Idaho Springs
DENVER
Bennett
Dillon
SUMMIT COUNTY
CLEAR CREEK COUNTY
PARK COUNTY
JEFFERSON COUNTY
Littleton
CHERRY CREEK RESERVOIR
ARAPAHOE COUNTY
ELBERT COUNTY
CONTINENTAL DIVIDE
Bailey
SOUTH PLATTE
Castle Rock
Kiowa
Agate
Leadville
Fairplay
DOUGLAS COUNTY
EL PASO COUNTY
TELLER COUNTY
Lake George
COLORADO SPRINGS

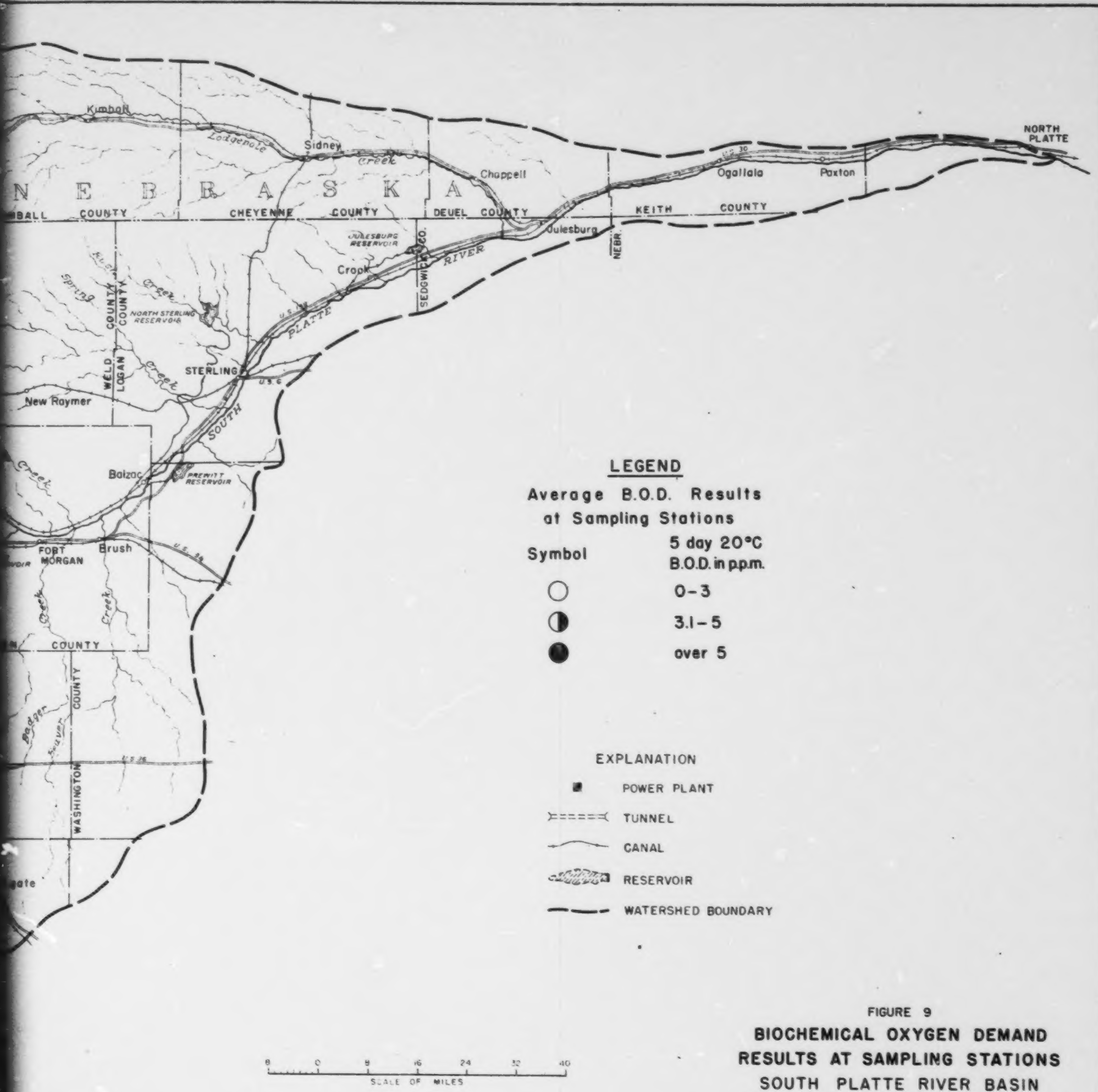
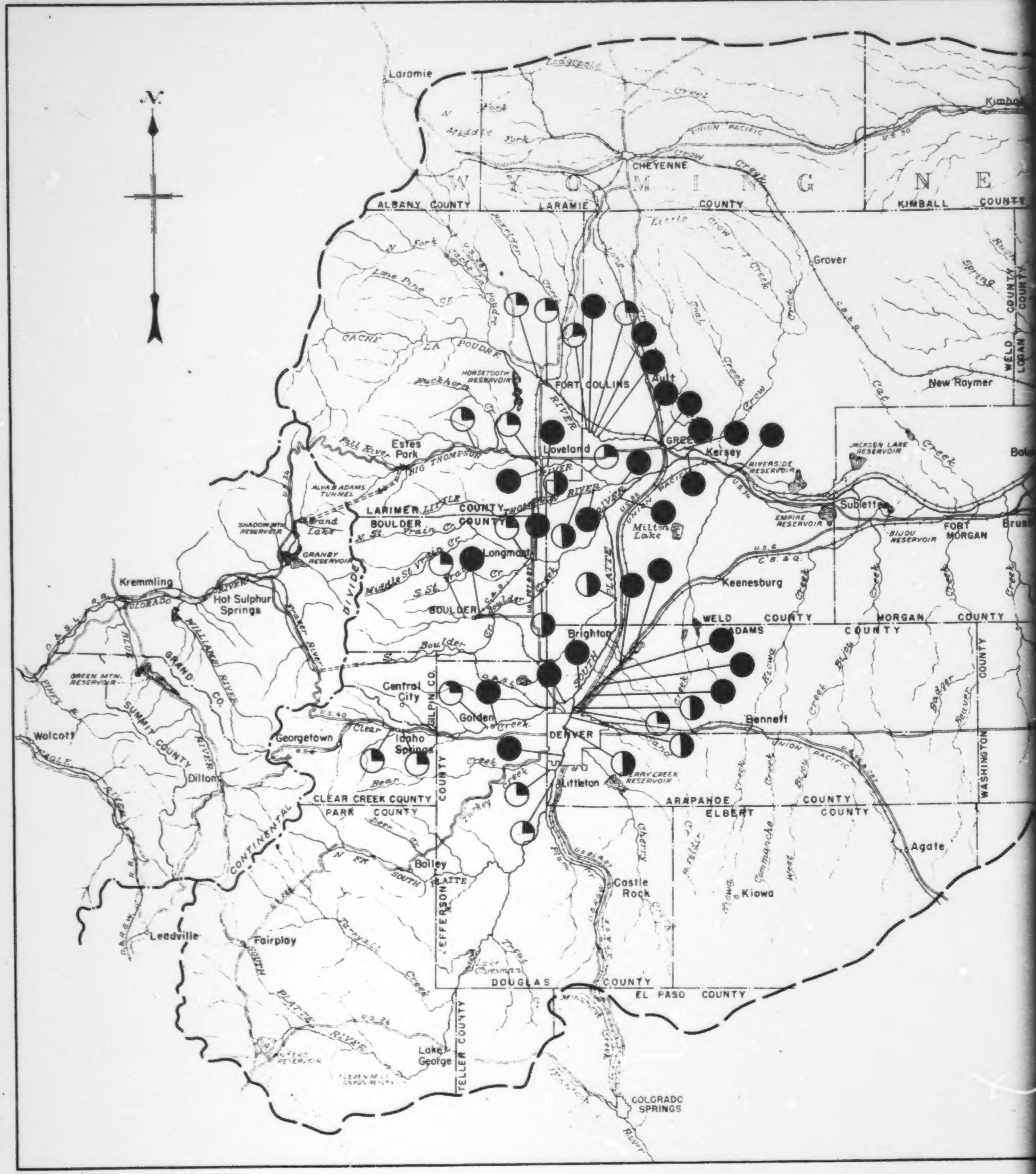

NORTH PLATTE
Kimball
Lodgepole
Sidney
Creek
Chappell
U.S. 30
Ogallala
Paxton
N E B R A S K A
BALL COUNTY
CHEYENNE COUNTY
DEUEL COUNTY
KEITH COUNTY
Julesburg
NEBR.
JULESBURG RESERVOIR
SEDGWICK CO.
RIVER
Crook
PLATTE
Spring
Creek
NORTH STERLING RESERVOIR
WELD COUNTY
LOGAN COUNTY
STERLING
U.S. 6
Creek
New Raymer
SOUTH
Creek
Balzac
PREWITT RESERVOIR
FORT MORGAN
Brush
U.S. 34
Creek
Creek
COUNTY
Badger
Beaver
WASHINGTON COUNTY
U.S. 36
gate
LEGEND
Average B.O.D. Results at Sampling Stations
Symbol
5 day 20°C B.O.D. in p.p.m.
○ 0-3
◐ 3.1-5
● over 5
EXPLANATION
POWER PLANT
TUNNEL
CANAL
RESERVOIR
WATERSHED BOUNDARY
8 0 8 16 24 32 40
SCALE OF MILES

FIGURE 9

BIOCHEMICAL OXYGEN DEMAND
RESULTS AT SAMPLING STATIONS
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
APRIL 1949


N.
Laramie
Cheyenne
WYOMING
NE
ALBANY COUNTY
LARAMIE COUNTY
KIMBALL COUNTY
Union Pacific
U.S. 30
Lodgepole Creek
Crow Creek
Little Crow Creek
Grover
Fort Collins
Ault
Greeley
Kersey
Loveland
Estes Park
Horsetooth Reservoir
Cache La Poudre River
Big Thompson River
Little Thompson River
Fall River
Alva B. Adams Tunnel
Grand Lake
Shadow Mtn. Reservoir
Granby Reservoir
Larimer County
Boulder County
Longmont
Boulder
St. Vrain Cr.
Milton Lake
Keenesburg
Riverside Reservoir
Jackson Lake Reservoir
Empire Reservoir
Bijou Reservoir
Sublette
Fort Morgan
New Raymer
Weld County
Logan County
Morgan County
Adams County
Washington County
Brighton
South Platte River
Denver
Golden
Central City
Gilpin Co.
Idaho Springs
Georgetown
Clear Creek County
Jefferson County
Bennett
Littleton
Cherry Creek Reservoir
Arapahoe County
Elbert County
Kiowa
Agate
Castle Rock
Douglas County
El Paso County
Colorado Springs
Park County
Bailey
Fairplay
Lake George
Teller County
Lake Cheesman
Eleven Mile Canyon Reservoir
Kremmling
Hot Sulphur Springs
Grand Co.
Colorado River
Williams River
Fraser River
Green Mtn. Reservoir
Summit County
Blue River
Dillon
Wolcott
Eagle River
Leadville
Continental Divide
Kimball
Brush
U.S. 6
C.B. & Q.
U.S. 40
U.S. 24
U.S. 85
U.S. 34
U.S. 287

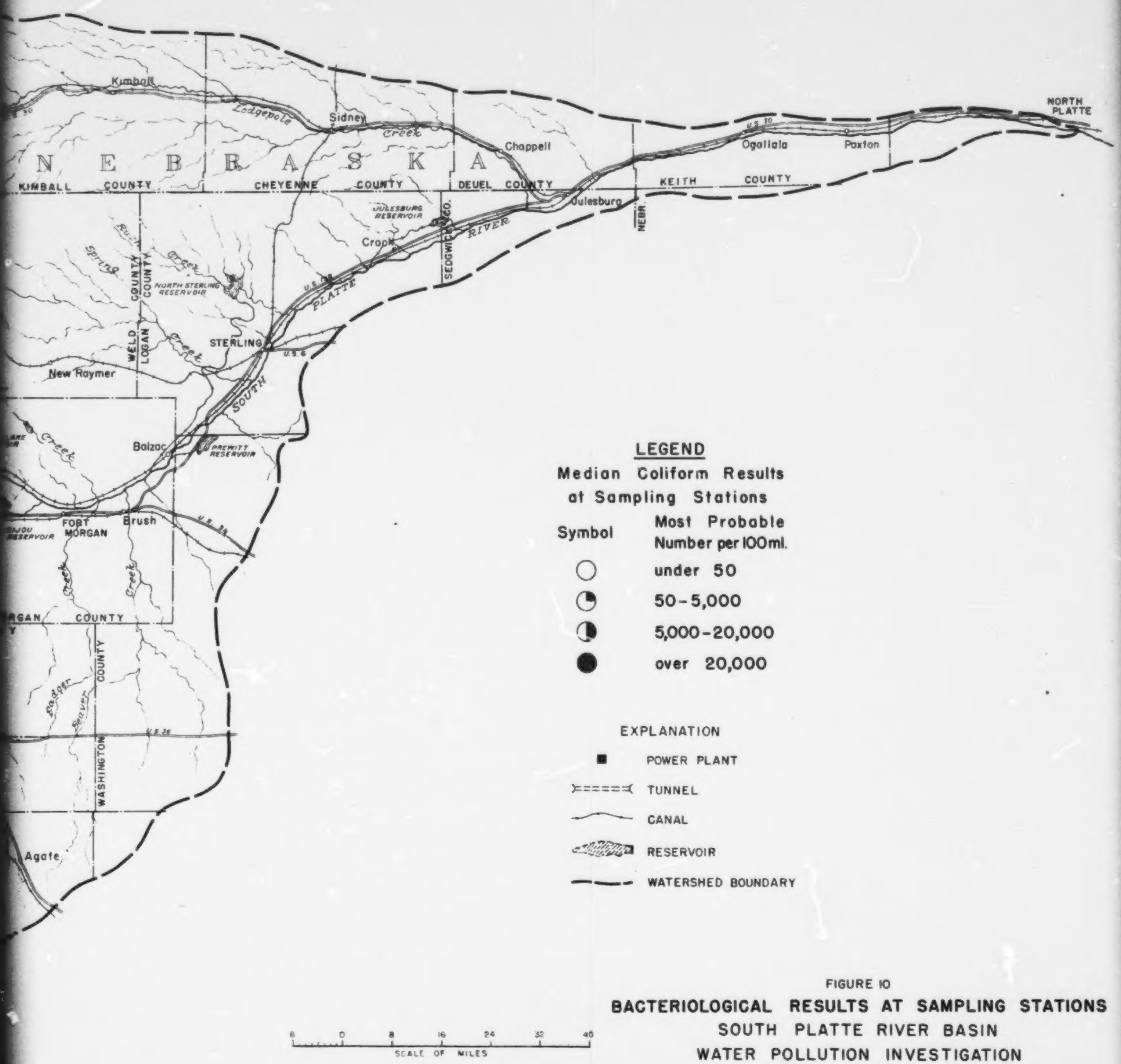

NEBRASKA
KIMBALL COUNTY
CHEYENNE COUNTY
DEUEL COUNTY
KEITH COUNTY
Kimball
Lodgepole
Sidney
Creek
Chappell
Ogallala
Paxton
NORTH PLATTE
U.S. 30
Julesburg
NEBR.
JULESBURG RESERVOIR
Crook
SEDGWICK CO.
SOUTH PLATTE RIVER
NORTH STERLING RESERVOIR
Spring
Creek
WELD COUNTY
LOGAN COUNTY
STERLING
U.S. 6
New Raymer
Balzac
PREWITT RESERVOIR
FORT MORGAN
Brush
BIJOU RESERVOIR
U.S. 34
MORGAN COUNTY
WASHINGTON COUNTY
Badger
Beaver
U.S. 36
Agate
LEGEND
Median Coliform Results at Sampling Stations
Symbol
Most Probable Number per 100ml.
○ under 50
◔ 50-5,000
◑ 5,000-20,000
● over 20,000
EXPLANATION
■ POWER PLANT
TUNNEL
CANAL
RESERVOIR
WATERSHED BOUNDARY
8 0 8 16 24 32 40
SCALE OF MILES

FIGURE 10

BACTERIOLOGICAL RESULTS AT SAMPLING STATIONS
SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
APRIL 1949

EXHIBITS

South Platte River Basin

Water Pollution Investigation

EXHIBIT I - Colorado-Big Thompson Project, Colorado . . . . Page 67

EXHIBIT II - Blue-South Platte Project . . . . Page 71

EXHIBIT I
(To accompany Map of Blue-South Platte Project)

COLORADO-BIG THOMPSON PROJECT
COLORADO

(Data Obtained from U. S. Bureau of Reclamation, Region 7, Denver, Colorado)

The Colorado-Big Thompson Project will provide for the stabilization of west slope waters and the diversion of surplus water from the headwaters of the Colorado River on the western slope of the Continental Divide to lands on the eastern slope in northeastern Colorado to supplement the present inadequate irrigation supply. An estimated average quantity of 310,000 acre-feet of water per annum is available for diversion from a point east of Grand Lake near the head of the Colorado River. This dependable supplemental supply will assure greater economic stability through reduction in drought hazards, more abundant crops, and increased income. Hydroelectric power will be developed from the water in its fall from the outlet of Alva B. Adams Tunnel to the eastern slope foothills reservoirs.

The general plan for the project provides for supplying supplemental water to approximately 615,000 acres of lands under cultivation as insurance against crop failure during dry seasons and the installation of a hydroelectric generator-capacity of approximately 175,500 kilowatts for industrial and domestic use.

Water from the Colorado River will be stored in the Granby Reservoir on the western slope and then lifted a maximum of 181 feet by the Granby Pumping Plant into Shadow Mountain Lake. From there the water will be diverted through the 13.07 mile Alva B. Adams Tunnel. It will then pass through a series of conduits and power plants and be stored in the three foothills reservoirs, namely, Carter Lake, Flatiron, and Horsetooth Reservoirs. Water will be released from these reservoirs through supply canals into the Big Thompson and Cache La Poudre Rivers and St. Vrain Creek, to be rediverted through existing canal systems to lands lying within the Northern Colorado Water Conservancy District.

To replace the water diverted from the western slope, Green Mountain Dam and Power Plant were constructed on Blue River, located 16 miles southeast of Kremmling, Colorado. The water stored in Green Mountain Reservoir is released at appropriate times to avoid interference by the transmountain diversions with existing water rights on the Colorado River. Incidental to these releases, hydroelectric power is being generated.

Construction and operation of the project will change the regimen of the Colorado River, requiring improvements and supplemental facilities for the irrigation of ranches and domestic use along the Colorado River between Granby Dam and Kremmling, Colorado. Construction of these improvements and facilities is in progress.

The power plant now in operation at Green Mountain Dam on the western slope and the power plants to be constructed on the eastern slope will be interconnected with the power plants of the North Platte, Kendrick, Riverton, EXHIBIT I (Continued)

and Shoshone Projects operated by the Bureau of Reclamation in Wyoming and serving distributing agencies in Wyoming, Nebraska, and Colorado.

Although the diversion of water for irrigation is the principal purpose of the project, about 600,000,000 kilowatt-hours of firm electrical energy per annum can be produced. This is sufficient to supply a city of 500,000 population. Power is being supplied to Rural Electric Associations in North-eastern Colorado for domestic use and for operating irrigation pumps.

The repayment contract authorized by a majority of all taxpayers in the Northern Colorado Water Conservancy District and approved by the Secretary of the Interior, cleared the way for the start of construction in 1938. The first large unit of work undertaken was the Green Mountain Dam and Power Plant, located sixteen miles southeast of Kremmling, Colorado which was completed and placed in operation in May 1943. This was followed by the Alva B. Adams Tunnel and Shadow Mountain Dam, both now completed. A start was made on Granby Reservoir in 1942, but this work was stopped for the duration of the war. Construction work begun in 1946 includes the Granby Dam, the Estes Aqueduct and Power System from the Adams Tunnel to the Big Thompson River, the Horsetooth Reservoir and Feeder Canal of the Foothills Reservoir and Canal System.

Construction of the Granby Dam and Dikes on the western slope was begun in the summer of 1946 and it is expected that three and one-half years will be required to complete the structures. The dam and four dikes are to be of the earth and rock-fill type. Granby Reservoir formed by this dam and dikes has a surface area, 7,256 acres and a maximum storage capacity of 546,000 acre-feet. It will provide the storage capacity for the western slope collection system and from it water will be pumped through the Granby Pump Canal into Shadow Mountain Reservoir and Grand Lake from which it will flow by gravity through the Adams Tunnel to the eastern slope.

The Ramshorn Tunnel and Prospect Mountain Tunnel are a part of the Estes Park Aqueduct and Power System. The Ramshorn Tunnel, which had been "holed through" in November 1946, will connect the Aspen Creek Siphon with the Marys Lake Penstock. It is a 1.3-mile by 10'0" diameter, horse-shoe shaped and concrete lined tunnel. Its designed capacity is 550 second-feet with a water depth of 8.3 feet. The Prospect Mountain Tunnel will connect the Prospect Mountain Conduit with the Estes Penstocks. It is a 1.0 mile-long, 12.5 feet diameter circular shaped and reinforced concrete lined tunnel. Its designed capacity is 1,300 second-feet flowing full and under pressure.

The Marys Lake Power Plant located about two miles south of the village of Estes Park, will be constructed to utilize the natural drop in the canal and tunnel system which carries water from the east portal of the Alva B. Adams Tunnel to the Big Thompson River below Estes Park. The plant will have one generating unit of 8100 kilowatt capacity and will operate under a maximum net head of 210 feet.

The Estes Power Plant is located on the south bank of the Big Thompson River about one-quarter mile below the village of Estes Park. It will contain three generating units, each consisting of a vertical shaft, hydraulic turbine operating under a net head of 510 feet, direct-connected to a 15,000 kilowatt generator.

The Horsetooth Reservoir, located on the eastern slope, is the furtherest downstream Foothills Storage Reservoir in the Project. It is located about five miles west of Fort Collins, Colorado, and will be the eastern slope storage reservoir for the Cache La Poudre River and its North Fork irrigation district. The reservoir, an off-stream storage type, will be formed by four earth and rock-fill dams and one dike of the same type. Horsetooth Reservoir will have a surface area of 1,873 acres and a total storage capacity of 147,322 acre-feet. The principal outlet will be to the north through Horsetooth Dam with a very small outlet to the east through Soldier Canyon Dam. Construction started in the summer of 1946.

The Flatiron Reservoir, with a useful capacity of about 5,000 acre-feet immediately north of the mountain by this name and located on Dry Creek, eight miles southwest of Loveland, has been added to the project plan to provide reregulation for power operations which will terminate at this reservoir, and to provide diversion for the St. Vrain Feeder leading south toward St. Vrain Creek and for the Horsetooth Feeder Canal leading to that reservoir. The Horsetooth Feeder Canal will also be provided a connection with Big Thompson River near its crossing of that stream. The various works described will enable full irrigation operations. Arkins Reservoir has been eliminated from the project plan and its capacity transferred to Horsetooth Reservoir.

The ultimate power development will provide for a total installed capacity of 175,500 kilowatts in seven plants, which will develop about 752,000,000 kilowatt-hours of electrical energy annually. The Marys Lake and Estes Plants, together with the Green Mountain, will develop approximately 240,000,000 kilowatt-hours annually. Less than one-sixth of this power will be required for project operations and the balance will be available for sale.

Construction of power plants between Estes Park and the Foothills Storage Reservoirs will be undertaken when justified by power markets. Meanwhile, the water will be turned into the Big Thompson River at the Estes Power Plant to be carried by that stream to the diversion dam located in Loveland Canyon, about nine miles west of the Town of Loveland and thence carried to the storage reservoirs of the Foothills Storage System.

The transmission system will consist of several units, one of which is a 69,000-volt circuit, 51.5 miles in length, connecting the power plant at Green Mountain Dam with the Granby Pumping Plant and the west portal of the Alva B. Adams Tunnel. Other lines to be built more immediately, comprise:

(a) Extension of the 115-kilovolt Greeley-Brush line to Sterling, Colorado, and a 69-kilovolt line from Sterling to Holyoke, and substations at Sterling and Holyoke with funds available for the 85-mile Brush-Sterling-Holyoke sections;

(b) A 38-mile 115-kilovolt line from Granby Pumping Plant over Buchanan Pass to Estes Park;

(70)

EXHIBIT I (Continued)

(c) A 31-mile 115-kilovolt line from the present terminus of the Estes Park to Loveland line to the Greeley Substation.

The lands to receive the supplemental supply of 310,000 acre-feet comprise 615,000 acres in northeastern Colorado.

There are 175,000 people living in the territory benefited by this project, who derive their livelihood either directly or indirectly from farming. The total actual value of all agricultural properties in the area, including equipment and livestock, now amounts to nearly $210,000,000.

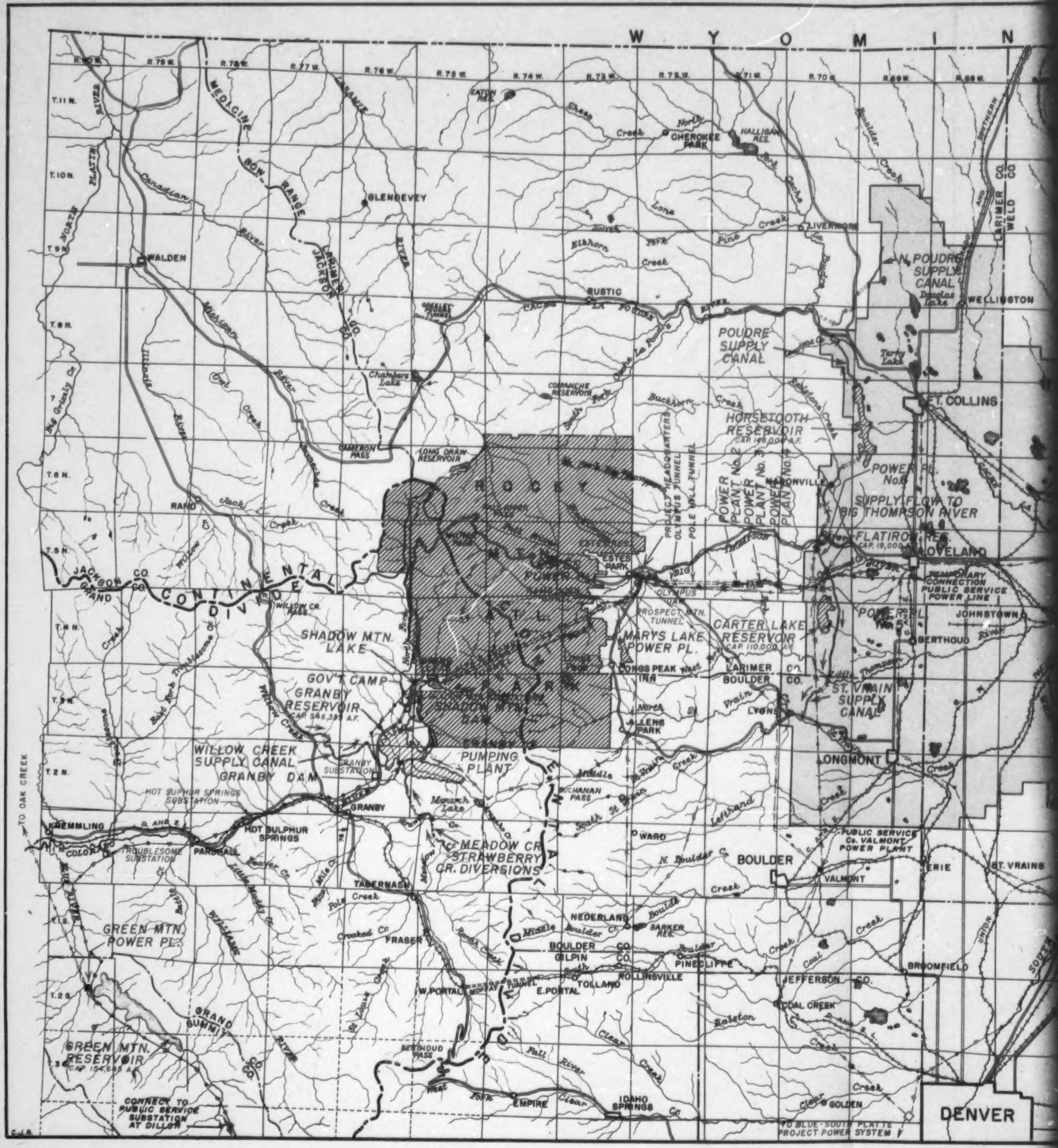
It has been estimated that there has been an average annual loss, prior to project construction, of $4,700,000 due to the shortage of irrigation water. With present prices, this amounts to about $7,000,000 per year. The supplemental water with prewar prices will increase crop and livestock production fully $13,000,000 annually. With present prices the crop increase would be fully $22,000,000. Increased crops mean increased population on the farms and much more in the towns and cities.

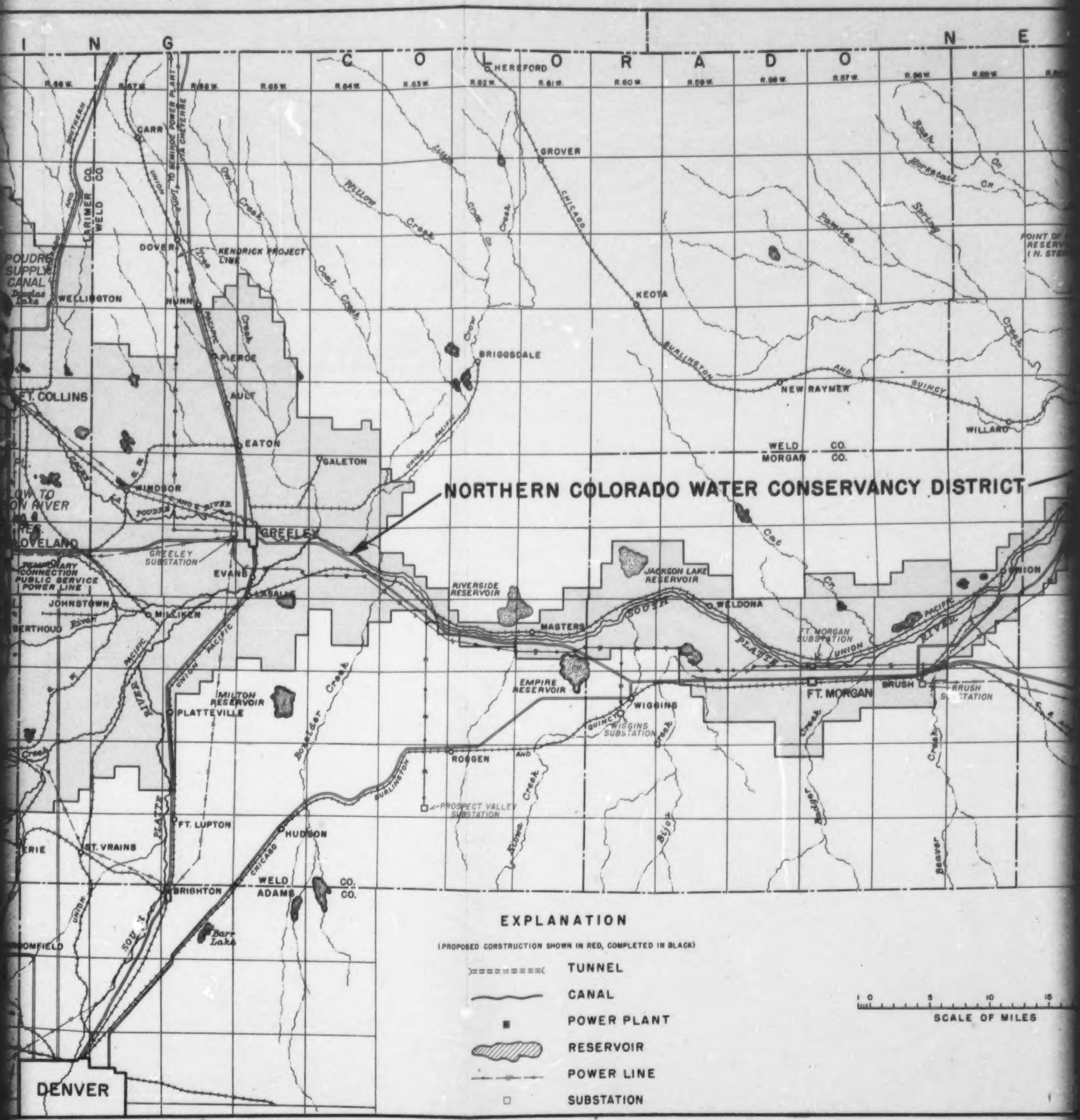
This project differs from Reclamation projects in public land areas, where the irrigation system, from the main canals to the individual farm laterals must be constructed, settlers brought in, buildings erected, and a large amount of work done before the farms and irrigation systems are going units. On this project irrigation systems are built, buildings are erected, and the settlers are producing crops on the land. The supplemental water will enable planting larger parts of the farm in years of shortage, and the maturing of planted crops, as well as more stabilized cropping practices. More higher value crops will be grown and more livestock and livestock products produced.

With the construction of the Colorado-Big Thompson Project, several outstanding recreational areas are being created. The reservoirs and adjacent areas will not only afford increased recreational use for hundred of thousands of Colorado residents, but also for countless numbers of nonresidents drawn here by Rocky Mountain National Park and other recreational centers. Fishing, boating, hiking, picnicking, and camping will be popular at most of the reservoir sites and one or two may even become winter sports areas. Granby Lake will be the second largest body of water in the State.

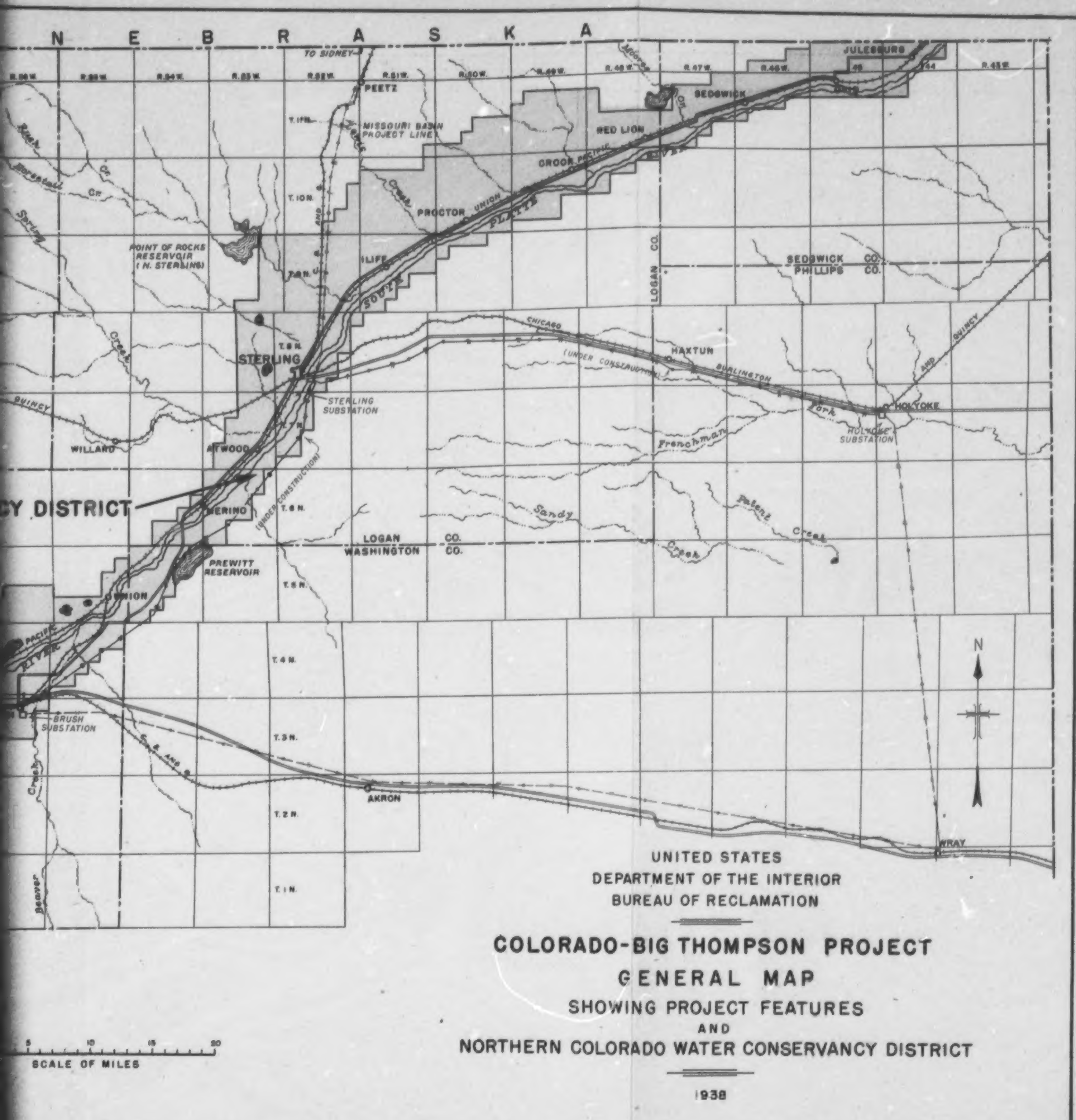
The great increase of recreational activities on this Project means that concessions, resorts, cabin camps and other facilities will have to be provided for the people using the areas. This should have an excellent effect upon the economy of Colorado and the Nation. Recreational benefits are estimated at more than $600,000 annually.

In order to get the greatest recreational use out of this project, the Bureau is working closely with other Federal and State agencies and with interested groups on the recreational planning for these areas.


W Y O M I N
R.79 W.
R.78 W.
R.77 W.
R.76 W.
R.75 W.
R.74 W.
R.73 W.
R.72 W.
R.71 W.
R.70 W.
R.69 W.
R.68 W.
T.11 N.
T.10 N.
T.9 N.
T.8 N.
T.6 N.
T.5 N.
T.4 N.
T.2 N.
T.1 S.
T.2 S.
EATON RES.
CHEROKEE PARK
HALLIGAN RES.
GLENDEVEY
WALDEN
LIVERMORE
N. POUDRE SUPPLY CANAL
Douglas Lake
WELLINGTON
RUSTIC
POUDRE SUPPLY CANAL
Terry Lake
FT. COLLINS
LARIMER CO.
WELD CO.
MEDICINE BOW RANGE
LARIMER CO.
JACKSON CO.
North Platte River
Canadian River
Michigan River
Illinois River
Owl Creek
Jack Creek
Willow Creek
Big Grizzly Cr.
Sheep Creek
North Fork
Lone Pine Creek
Elkhorn Creek
Cache La Poudre River
GREELEY-POUDRE TUNNEL
Chambers Lake
COMANCHE RESERVOIR
CAMERON PASS
LONG DRAW RESERVOIR
Buckhorn Creek
HORSETOOTH RESERVOIR
CAP. 146,000 A.F.
PROJECT HEADQUARTERS
OLYMPUS TUNNEL
POLE HILL TUNNEL
POWER PLANT No. 2
POWER PLANT No. 3
POWER PLANT No. 4
MASONVILLE
POWER PL. No. 6
SUPPLY FLOW TO BIG THOMPSON RIVER
FLATIRON RES.
CAP. 19,000 A.F.
LOVELAND
TEMPORARY CONNECTION PUBLIC SERVICE POWER LINE
JOHNSTOWN
ROCKY MTN. NATL. PARK
ESTES PARK
BIG THOMPSON
OLYMPUS DAM
PROSPECT MTN. TUNNEL
MARYS LAKE POWER PL.
CARTER LAKE RESERVOIR
CAP. 110,000 A.F.
POWER PL. No. 5
BERTHOUD
Little Thompson
RAND
JACKSON CO.
GRAND CO.
CONTINENTAL DIVIDE
WILLOW CR. PASS
SHADOW MTN. LAKE
GOV'T CAMP
GRANBY RESERVOIR
CAP. 546,395 A.F.
SHADOW MTN. DAM
GRANBY PUMPING PLANT
WILLOW CREEK SUPPLY CANAL
GRANBY DAM
GRANBY SUBSTATION
HOT SULPHUR SPRINGS SUBSTATION
GRANBY
LONGS PEAK INN
LARIMER CO.
BOULDER CO.
ST. VRAIN SUPPLY CANAL
LYONS
ALLENS PARK
North St. Vrain
LONGMONT
BUCHANAN PASS
Middle St. Vrain Creek
South St. Vrain
Lefthand
WARD
TO OAK CREEK
KREMMLING
D. AND S.
COLORADO
TROUBLESOME SUBSTATION
PARSHALL
HOT SULPHUR SPRINGS
Monarch Lake
MEADOW CR. STRAWBERRY CR. DIVERSIONS
PUBLIC SERVICE Co. VALMONT POWER PLANT
BOULDER
VALMONT
ERIE
ST. VRAINS
N. Boulder C.
TABERNASH
Pole Creek
Crooked Cr.
FRASER
GREEN MTN. POWER PL.
NEDERLAND
BARKER RES.
BOULDER CO.
GILPIN CO.
PINECLIFFE
ROLLINSVILLE
TOLLAND
BROOMFIELD
JEFFERSON CO.
COAL CREEK
W. PORTAL
MOFFAT TUNNEL
E. PORTAL
GRAND SUMMIT CO.
GREEN MTN. RESERVOIR
CAP. 154,645 A.F.
BERTHOUD PASS
Fall River
Clear Creek
Ralston
EMPIRE
IDAHO SPRINGS
GOLDEN
CONNECT TO PUBLIC SERVICE SUBSTATION AT DILLON
TO BLUE-SOUTH PLATTE PROJECT POWER SYSTEM
DENVER



NORTHERN COLORADO WATER CONSERVANCY DISTRICT
COLORADO
EXPLANATION
(PROPOSED CONSTRUCTION SHOWN IN RED, COMPLETED IN BLACK)
TUNNEL
CANAL
POWER PLANT
RESERVOIR
POWER LINE
SUBSTATION
SCALE OF MILES
0 5 10 15
R.68W.
R.67W.
R.66W.
R.65W.
R.64W.
R.63W.
R.62W.
R.61W.
R.60W.
R.59W.
R.58W.
R.57W.
R.56W.
R.55W.
HEREFORD
GROVER
CARR
DOVER
KENDRICK PROJECT LINE
POUDRE SUPPLY CANAL
Douglas Lake
WELLINGTON
NUNN
PIERCE
AULT
EATON
GALETON
BRIGGSDALE
KEOTA
NEW RAYMER
WILLARD
WELD CO.
MORGAN CO.
LARIMER CO.
WELD CO.
FT. COLLINS
WINDSOR
GREELEY
LOVELAND
GREELEY SUBSTATION
TEMPORARY CONNECTION PUBLIC SERVICE POWER LINE
EVANS
LA SALLE
JOHNSTOWN
MILLIKEN
BERTHOUD
RIVERSIDE RESERVOIR
JACKSON LAKE RESERVOIR
MASTERS
WELDONA
FT. MORGAN SUBSTATION
FT. MORGAN
BRUSH
BRUSH SUBSTATION
UNION
EMPIRE RESERVOIR
WIGGINS
WIGGINS SUBSTATION
MILTON RESERVOIR
PLATTEVILLE
ROGGEN
PROSPECT VALLEY SUBSTATION
FT. LUPTON
HUDSON
ERIE
FT. VRAINS
BRIGHTON
WELD CO.
ADAMS CO.
Barr Lake
BROOMFIELD
DENVER
POINT OF RESERV (N. STER
SOUTH PLATTE RIVER
Willow Creek
Crow Cr
Coal Creek
Owl Creek
Lone Tree Creek
Cat Cr
Pawnee Creek
Horsetail Cr
Spring Creek
Box Elder Creek
Kiowa Creek
Bijou Creek
Badger Creek
Beaver Creek
Big Thompson River
CHICAGO BURLINGTON AND QUINCY
UNION PACIFIC
COLORADO AND SOUTHERN
TO SEMINOE POWER PLANT VIA CHEYENNE
POUDRE AND S. RIVER


NEBRASKA
TO SIDNEY
R.56W.
R.55W.
R.54W.
R.53W.
R.52W.
R.51W.
R.50W.
R.49W.
R.48W.
R.47W.
R.46W.
R.45W.
JULESBURG
SEDGWICK
PEETZ
T.11N.
MISSOURI BASIN PROJECT LINE
RED LION
CROOK
PACIFIC
UNION
PROCTOR
PLATTE
SOUTH
RIVER
ILIFF
T.10N.
T.9N.
T.8N.
T.7N.
T.6N.
T.5N.
T.4N.
T.3N.
T.2N.
T.1N.
POINT OF ROCKS RESERVOIR (N. STERLING)
STERLING
STERLING SUBSTATION
LOGAN CO.
SEDGWICK CO.
PHILLIPS CO.
CHICAGO
BURLINGTON
AND QUINCY
HAXTUN
(UNDER CONSTRUCTION)
HOLYOKE
HOLYOKE SUBSTATION
Frenchman
Fork
Sandy
Creek
Patent
Creek
WILLARD
QUINCY
ATWOOD
MERINO
(UNDER CONSTRUCTION)
CY DISTRICT
LOGAN CO.
WASHINGTON CO.
PREWITT RESERVOIR
UNION
PACIFIC
RIVER
BRUSH SUBSTATION
C. B. AND Q.
AKRON
WRAY
Beaver Creek
N
5
10
15
20
SCALE OF MILES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

COLORADO-BIG THOMPSON PROJECT
GENERAL MAP
SHOWING PROJECT FEATURES
AND
NORTHERN COLORADO WATER CONSERVANCY DISTRICT

1938

REVISED JUNE 1939
REVISED MARCH 1946
REVISED JUNE 10, 1947

245-D-259

SMITH-BROOKS, DENVER 5000 6-47

EXHIBIT II

(To accompany Map of Blue-South Platte Project)

BLUE-SOUTH PLATTE PROJECT

(Synopsis of talk given before meeting of Colorado Section
American Society of Civil Engineers on January 10, 1949
by J. M. Barrett) *

Development of the potential multiple-purpose Blue-South Platte Project would greatly augment the present limited supplies of water and electrical energy and is vitally important to the expanding agricultural and industrial economy of the upper South Platte River Basin.

Irrigation farming was started in this area in 1859 near Golden, Colorado. From this beginning, irrigation agriculture has grown to be the leading industry of the State. The growth of irrigation followed the pattern so common in the history of the West. An abundance of good land and the illusion of an unlimited supply of water in the streams brought about an expansion far in excess of the water supply actually available. The result is that thousands of acres of land now irrigated fall far short of their potential production because of a chronic shortage of irrigation water.

The effects of over-expansion and the possibility of supplementing South Platte water supplies with Western Slope diversions were recognized as early as 1889 when Hiram Prince addressed the State Legislature and asked for $25,000 to be used for finding a transbasin diversion route. In 1898, the water users in the Cache La Poudre area started construction of the "Grand River Ditch" to divert from the headwaters of the Grand (now the Colorado) River to the headwaters of the Cache La Poudre River.

Because of increasing needs for municipal water, the city of Denver in 1910, started investigating possible methods of importing water from the Western Slope. In 1936, the city's first diversion was made from the Fraser River watershed; however, further investigation and development has been continuous to the present time.

In 1936, the Bureau of Reclamation was authorized to start a comprehensive investigation of all water requirements of the upper South Platte Basin and the feasibility of supplying these requirements by importation of water from the Colorado River watershed. A report on one possible diversion scheme was completed in 1940 but was never approved nor released. The investigation was reopened by the Bureau in 1942 and has been continuous since that time. In November 1948, a preliminary draft of the planning report of the multiple-purpose Blue-South Platte Project was completed. This report is now being informally reviewed by various State and Government agencies. The reviewers' criticisms will be considered and the report revised to incorporate such changes as are justified. The revised report will then be transmitted through proper channels for approval and release.

Throughout the investigation, the Bureau has enjoyed the full-hearted cooperation of the city of Denver, the State of Colorado, and all interested private and Government agencies.

*J. M. Barrett, Planning Engineer, Bureau of Reclamation, Denver, Colorado.

EXHIBIT II (Continued)

In the course of the Bureau's investigation, all phases of the project plan and the effects of project development have been extensively studied. Hydrologic studies were made to determine the amount of water which could be feasibly diverted from the Colorado River watershed. Studies in which the actual operation of the entire collection, diversion, and utilization system was simulated were made to establish the most economic and advantageous arrangement and capacity of canals, reservoirs, powerplants, and other facilities.

Extensive surveys of canal, tunnel, and reservoir sites were made. Geologic examinations and explorations were made of damsites, tunnel sites, and deposits of construction materials. Rough preliminary plans and cost estimates were prepared for all project features.

The field of irrigation and industrial economics has been thoroughly investigated by specialists in these fields. Their studies have included soil classification, present and potential agricultural practices and development, industrial development and potentiality, evaluation of benefits which would result from construction and operation of the project, and determination of the ability of the various users of project facilities and products to repay the costs of construction and operation of the project.

The possibility of using the water supply developed by the project for the generation of hydroelectric power has been critically examined. These studies were closely coordinated with the water supply studies in order to plan for the maximum use of the project for both water and power production. The location, capacity, and cost of power facilities have been determined. A survey of the power market area has been completed, showing the present and estimated future power requirements within the areas.

The incidental or secondary uses which project facilities might serve have also been studied. The possibility of providing some control of floods and the retention of sediment in the contemplated reservoirs have been investigated. The effect of the project operation on the problem of stream pollution has been studied. The National Park Service has considered the use of project facilities for recreational purposes. The Fish and Wildlife Service has investigated the effects of the project on the fish and game resources of the area.

The comprehensive plan for the development of the Blue-South Platte Project, as at present envisioned, would accomplish the following purposes:

1. Fully utilize the water supply of the upper South Platte Basin and supplement that supply through the annual importation of 430,000 acre-feet of water from the Colorado River Basin, specifically from the Eagle, Piney, Blue, and Williams River watersheds.

EXHIBIT II (Continued)

2. The increased water supply would supplement the water supply of 264,000 acres of land now irrigated and permit their full production; a full water supply would be furnished to 83,000 acres of land now dry-farmed; the increased application of water to these lands would inadvertently recharge existing underground reservoirs and permit the full development of 29,000 acres through pumping from groundwater.

3. Supplemental supplies of municipal water would be furnished to existing systems and permit the expansion of the Denver Metropolitan Area (Denver and surrounding communities) to a population of 1,000,000 or greater.

4. Produce annually 1,059,500,000 kilowatthours of marketable electric energy.

In operation, the project would collect, regulate, and divert the unused runoff from the upper watershed of the Eagle, Piney, Blue, and Williams Rivers. The water collected from these sources would be stored and controlled in a reservoir to be constructed on the Snake River above Dillon, Colorado. From this reservoir, diversion would be made to the North Fork of the South Platte River through an 18.4-mile long tunnel (the Montezuma Tunnel) through the Continental Divide. Between the outlet of the Montezuma Tunnel and the principal Eastern Slope storage reservoir to be constructed at the junction of the North Fork and main South Platte Rivers, the water would pass through a series of powerplants to utilize fully a drop in elevation of 2,507 feet.

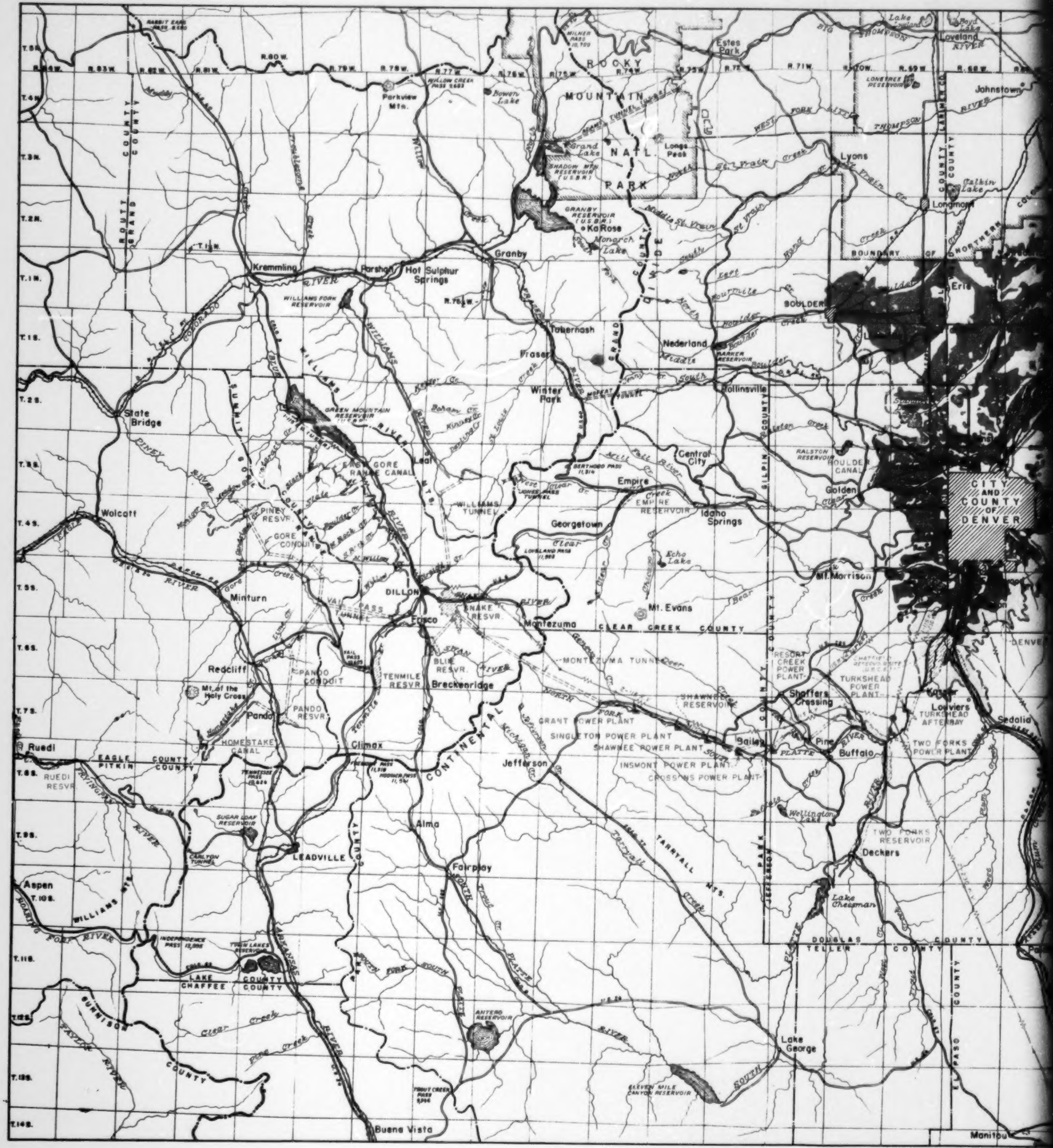
Water would be released from Two Forks Reservoir to meet the water requirements of the irrigators in the area south of the Colorado-Big Thompson Project, to meet the municipal requirements of the Denver Metropolitan Area, and for the production of power at the Two Forks and Turkshead plants. The reservoir could also serve the Colorado Springs area by providing exchange water for that city's potential diversions from the South Platte.

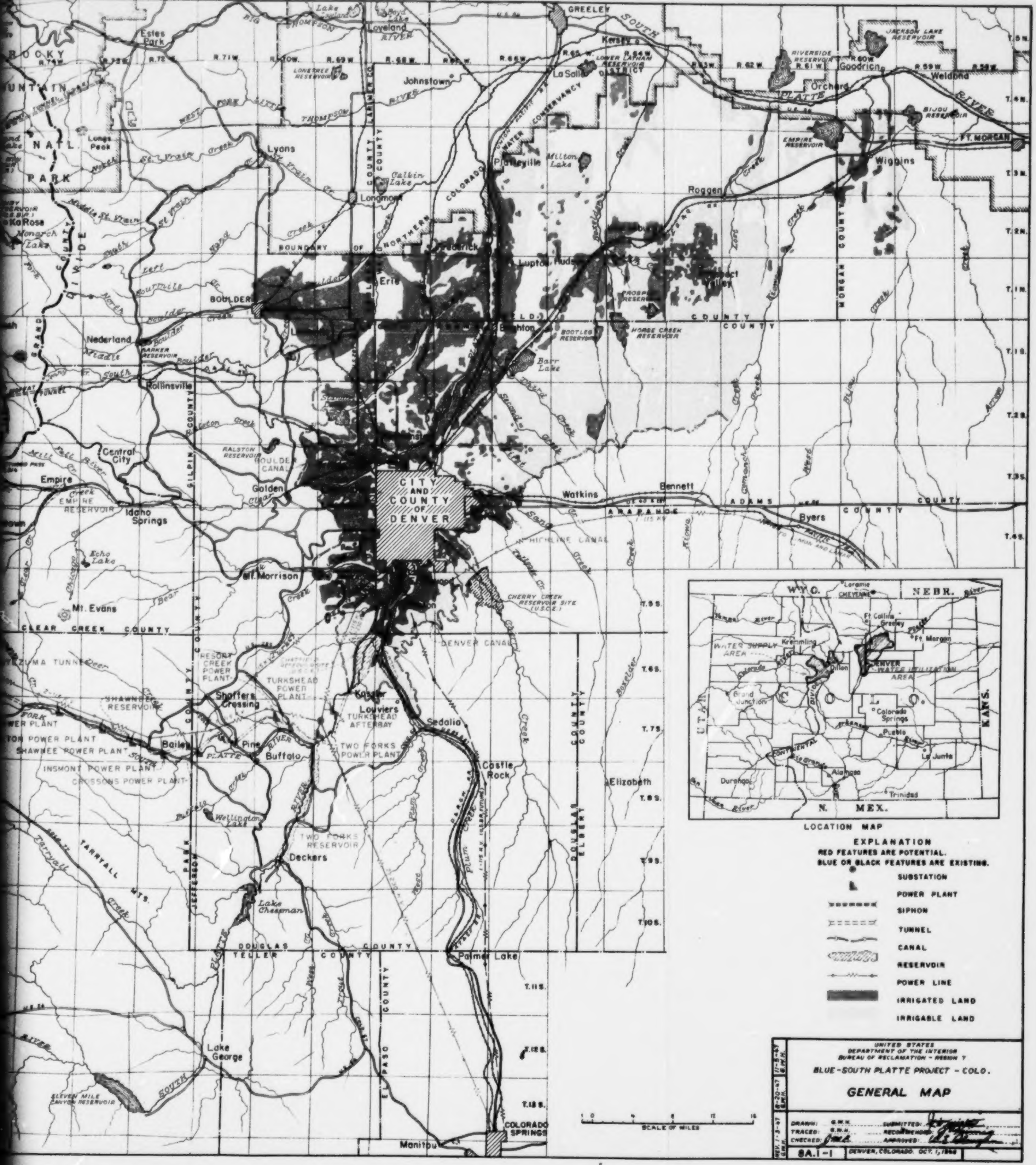
In observance of a fundamental principle governing the diversion of Western Slope water to the Eastern Slope, the project plan includes replacement storage facilities for the full protection of present and possible future users of water for irrigation, domestic, or industrial purposes in the Colorado River Basin.

The works necessary to accomplish the purposes of the project would include: 80 miles of collection canals, 83 miles of collection and diversion tunnels, 21 miles of power conduits, 137 miles of distribution canals in the irrigated area, 9 principal storage reservoirs with a total capacity of 1,189,000 acre-feet, 8 hydroelectric power-plants with a total installed capacity of 265,800 kilowatts, and transmission lines and substations necessary to conduct power to the load centers.

EXHIBIT II (Continued)

An extensive economic and financial analysis of the project indicates it to be entirely feasible. The estimated total cost of the project would be about $400,000,000, based on 1947 price levels. This cost would be allocated to the primary purposes of the project--irrigation, municipal water, and power--and, to a less extent, to sediment control and recreation. Payments by irrigation and municipal water users and revenues from the sale of power would provide for the repayment of all reimbursable construction costs, in accordance with present Reclamation law. The benefits which would be derived from the project construction and operation have been evaluated on the basis of average prices during the 1939 to 1944 period. The ratio of the project costs to the benefits derived is 1.43 to 1 which indicates it to be a sound investment of public money.


ROCKY MOUNTAIN NATL. PARK
Estes Park
Loveland
Johnstown
Lyons
Longmont
Grand Lake
Shadow Mtn. Reservoir (U.S.B.R.)
Granby Reservoir (U.S.B.R.)
Monarch Lake
Granby
Kremmling
Parshall
Hot Sulphur Springs
Williams Fork Reservoir
Parkview Mtn.
Willow Creek Pass
Bowen Lake
Tabernash
Fraser
Winter Park
Nederland
Barker Reservoir
Boulder
Erie
Rollinsville
Central City
Empire
Georgetown
Idaho Springs
Golden
Ralston Reservoir
Boulder Canal
CITY AND COUNTY OF DENVER
Mt. Morrison
Echo Lake
Mt. Evans
Clear Creek County
Berthoud Pass
Loveland Pass
Jones Pass Tunnel
Williams Tunnel
Empire Reservoir
State Bridge
Green Mountain Reservoir
East Gore Range Canal
Wolcott
Piney Resvr.
Gore Conduit
Minturn
Dillon
Frisco
Vail Pass Tunnel
Snake Resvr.
Montezuma
Montezuma Tunnel
Redcliff
Mt. of the Holy Cross
Pando
Pando Conduit
Pando Resvr.
Homestake Canal
Tenmile Resvr.
Blue Resvr.
Breckenridge
Climax
Continental Divide
Jefferson
Grant Power Plant
Singleton Power Plant
Shawnee Power Plant
Insmont Power Plant
Crossons Power Plant
Shawnee Reservoir
Resort Creek Power Plant
Turkshead Power Plant
Turkshead Afterbay
Shaffers Crossing
Bailey
Pine
Buffalo
Louviers
Sedalia
Two Forks Power Plant
Two Forks Reservoir
Wellington Lake
Deckers
Lake Cheesman
Ruedi
Ruedi Resvr.
Eagle County
Pitkin County
Sugar Loaf Reservoir
Leadville
Alma
Fairplay
Carlton Tunnel
Aspen
Independence Pass
Twin Lakes Reservoir
Lake County
Chaffee County
Antero Reservoir
Eleven Mile Canyon Reservoir
Lake George
Tarryall Mts.
Trout Creek Pass
Buena Vista
Manitou
Douglas County
Teller County
El Paso County
Park County
Jefferson County
Gilpin County
Routt County
Grand County
Summit County
Gunnison County
Colorado River
Blue River
Williams River
Eagle River
Piney River
Arkansas River
Roaring Fork River
Frying Pan River
South Platte River
Middle St. Vrain
Big Thompson River
T. 5 N.
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
T. 5 S.
T. 6 S.
T. 7 S.
T. 8 S.
T. 9 S.
T. 10 S.
T. 11 S.
T. 12 S.
T. 13 S.
T. 14 S.
R. 84 W.
R. 83 W.
R. 82 W.
R. 81 W.
R. 80 W.
R. 79 W.
R. 78 W.
R. 77 W.
R. 76 W.
R. 75 W.
R. 74 W.
R. 73 W.
R. 72 W.
R. 71 W.
R. 70 W.
R. 69 W.
R. 68 W.



GREELEY
Estes Park
Loveland
Lake Loveland
Boyd Lake
Big Thompson River
South Platte River
Kersey
La Salle
Lower Latham Reservoir
Riverside Reservoir
Jackson Lake Reservoir
Goodrich
Weldona
Orchard
Bijou Reservoir
Empire Reservoir
Ft. Morgan
Wiggins
Johnstown
Lonetree Reservoir
Rocky Mountain Natl. Park
Longs Peak
Lyons
St. Vrain Creek
Longmont
Calbin Lake
Platteville
Milton Lake
Roggen
Colorado Water Conservancy District
Boundary of Northern Colorado Water Conservancy District
Frederick
Erie
Lupton
Hudson
Prospect Valley
Prospect Reservoir
Boulder
Nederland
Barker Reservoir
Rollinsville
Brighton
Bootleg Reservoir
Horse Creek Reservoir
Barr Lake
Ralston Reservoir
Boulder Canal
Central City
Empire
Golden
Idaho Springs
Empire Reservoir
Echo Lake
City and County of Denver
Watkins
Bennett
Byers
Adams County
Arapahoe County
Highline Canal
Mt. Morrison
Mt. Evans
Clear Creek County
Cherry Creek Reservoir Site (U.S.C.E.)
Denver Canal
Resort Creek Power Plant
Turkshead Power Plant
Shawnee Reservoir
Shaffers Crossing
Kassler
Louviers
Turkshead Afterbay
Sedalia
Bailey
Pine
Buffalo
Two Forks Power Plant
Inismont Power Plant
Crossons Power Plant
Shawnee Power Plant
Castle Rock
Elizabeth
Wellington Lake
Two Forks Reservoir
Deckers
Lake Cheesman
Tarryall Mts.
Jefferson County
Park County
Douglas County
Elbert County
Teller County
El Paso County
Palmer Lake
Lake George
Eleven Mile Canyon Reservoir
Manitou
Colorado Springs
Plum Creek
Cherry Creek
Kiowa Creek
Bijou Creek
Beaver Creek
Box Elder Creek
Continental Divide
T.5N.
T.4N.
T.3N.
T.2N.
T.1N.
T.1S.
T.2S.
T.3S.
T.4S.
T.5S.
T.6S.
T.7S.
T.8S.
T.9S.
T.10S.
T.11S.
T.12S.
T.13S.
R.73W.
R.72W.
R.71W.
R.70W.
R.69W.
R.68W.
R.67W.
R.66W.
R.65W.
R.64W.
R.63W.
R.62W.
R.61W.
R.60W.
R.59W.
R.58W.
WYO.
NEBR.
KANS.
UTAH
N. MEX.
COLO.
Laramie
Cheyenne
Ft. Collins
Greeley
Ft. Morgan
Kremmling
Dillon
Denver
Water Supply Area
Water Utilization Area
Grand Junction
Colorado Springs
Pueblo
La Junta
Durango
Alamosa
Trinidad
0 4 8 12 16
SCALE OF MILES

LOCATION MAP

EXPLANATION

RED FEATURES ARE POTENTIAL.
BLUE OR BLACK FEATURES ARE EXISTING.

●	SUBSTATION
◣	POWER PLANT
▬	SIPHON
┅	TUNNEL
〰	CANAL
▨	RESERVOIR
⟿	POWER LINE
■	IRRIGATED LAND
░	IRRIGABLE LAND

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION - REGION 7

BLUE-SOUTH PLATTE PROJECT - COLO.

GENERAL MAP

DRAWN: G.W.H.
TRACED: G.W.H.
CHECKED: J.M.A.
SUBMITTED:
RECOMMENDED:
APPROVED:

REV. 1-3-47 G.W.H.
8-20-47 G.W.H.
11-5-47 G.W.H.

8A.1-1

DENVER, COLORADO. OCT. 1, 1946

APPENDICES

South Platte River Basin

Water Pollution Investigation

Appendix	Title	Page No.
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"C"	Stream Pollution Survey of the Portions of the South Platte River and Cherry Creek Which Lie Within The City and County of Denver	83
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APPENDIX "A"

MEMORANDUM OF UNDERSTANDING RESPECTING JOINT PROGRAM FOR STREAM POLLUTION INVESTIGATIONS OF THE SOUTH PLATTE RIVER BASIN

1. THIS MEMORANDUM OF UNDERSTANDING, made and entered into this 20 day of July 1948, pursuant to the authority contained in the Acts of June 17, 1902 (32 Stat. 388), and acts amendatory thereof or supplementary thereto, known as the Reclamation Laws; the Act of December 22, 1944 (48 Stat. 887), by and between the BUREAU OF RECLAMATION and the COLORADO STATE DIVISION OF PUBLIC HEALTH represented by the contracting officer executing this agreement, and the HEALTH DEPARTMENT OF THE CITY OF DENVER, COLORADO, also represented by the contracting officer executing this agreement on its behalf; all as parties of the first part; and the PUBLIC HEALTH SERVICE, as party of the second part.

WITNESSETH, THAT:

2. WHEREAS, the Bureau of Reclamation is now engaged in the construction of the Missouri Basin Project, and it has been determined by such agency and the health departments of the State of Colorado and the City of Denver, Colorado, that it is necessary to conduct a study of stream pollution in the South Platte River Basin in order to secure data for use in planning maximum water utilization in such basin as a part of the general plans for the Missouri River Basin Project, and that such study should include, among other things: (a) The extent, types and major sources of pollution; (b) A review of existing State laws in Colorado and Wyoming and pending legislation regarding pollution of public waters; (c) Determine bacteriological quality of water for irrigation uses at present and proposed diversion points and in existing canals; (d) Minimum stream flows necessary below the reservoirs for public water supplies and for sanitation purposes with present and contemplated pollution; (e) Public water supply needs; (f) Possible benefits to abatement of water pollution problems by reservoir releases; and (g) Recommendations and existing plans for pollution abatement; and

3. WHEREAS, the Bureau of Reclamation and the State of Colorado and the City of Denver do not have the necessary trained and experienced personnel required to perform the pollution survey and study contemplated herein, and do not have all of the necessary equipment required for such a study, and it is necessary therefore to request the Public Health Service to conduct the stream pollution survey of the South Platte River and its tributaries, and the said Public Health Service is willing to conduct such survey on the terms and conditions hereinafter set forth,

NOW, THEREFORE, it is mutually understood and agreed by and between the parties hereto as follows:

4. Beginning on or about July 1, 1948, or as soon thereafter as feasible, and continuing for a period of approximately one year thereafter:

APPENDIX "A" (Continued)

(a) The Public Health Service will conduct a stream pollution survey of the South Platte River and its tributaries, which survey will include, among others, the items set forth in Article 2 hereof. The personnel involved in making such a survey shall be under the supervision of the Public Health Service during their work on the pollution survey. The Public Health Service shall assume full responsibility for the survey and the preparation of complete reports thereon. An interim report will be submitted by April 1949 and a final report which will include the findings, conclusions, and recommendations will be submitted as soon as practicable after the completion of field work but not later than July 1, 1950. The number of copies of the reports furnished to the participating agencies shall be as follows: 20 copies each to the Bureau of Reclamation and the State of Colorado, and 10 copies to the City of Denver. In addition, the Public Health Service will consult with the health officials of the States of Nebraska and Wyoming relative to their pollution problems as involved in the South Platte River Basin, and copies of the reports made by the Public Health Service will be furnished to these States.

(b) In connection with the survey contemplated herein, the Public Health Service will furnish, as required, the following services and facilities:

One (1) mobile laboratory unit.
Two (2) sanitary engineers (part time).
One (1) bacteriologist (part time).
One (1) chemist (part time).
One (1) biologist (part time).

(c) The Bureau of Reclamation will pay not to exceed $35,000 of the actual costs incurred by the Public Health Service in making the stream pollution survey. Payments will be made monthly upon receipt of certified vouchers.

In addition the Bureau of Reclamation will supply for the use of the Public Health Service in connection with the stream pollution survey such of the following as may be required by the Public Health Service:

(1) Drafting assistance.
(2) Maps, charts, hydrologic and other available data.
(3) 4 automobiles including all maintenance and operational expenses for the three sample collectors and the engineer in charge.

(d) The Colorado State Department of Health will provide the following for the use of the Public Health Service:

Laboratory services at Denver, Colorado, to the extent of 50 samples per week.

APPENDIX "A" (Continued)

Laboratory services at Greeley, Colorado, to the extent of 30 samples per week.

One (1) sanitary Engineer, half-time and travel.

The estimated value of such above-mentioned services is $11,300.

(e) The Health Department of the City of Denver, as its part of this cooperative agreement, will not share in the actual costs incurred by the Public Health Service in making such stream pollution survey, but will provide the following for use of the Public Health Service:

One (1) sanitary engineer, one-half of his time and travel.

The estimated value of such above-mentioned services is $2,500.

5. Where the operations of this contract extend beyond the fiscal year 1949 the contract is contingent upon appropriations to the U. S. Public Health Service for expenditures hereunder beginning July 1, 1949. In case such appropriations as may be necessary to carry out this contract are not made, the State and City agencies who are parties hereto release the United States from all liability due to the failure of the Congress to make such appropriation.

6. No Member of or Delegate to Congress or Resident Commissioner shall be admitted to any share or part of this contract or to any benefit that may arise herefrom, but this restriction shall not be construed to extend to this contract if made with a corporation or company for its general benefit.

IN WITNESS WHEREOF, The parties hereto have caused this memorandum of agreement to be executed as of the day and date first above written.

BUREAU OF RECLAMATION

By /s/ W. E. BLOMGREN
Acting Regional Director Region 7
Denver, Colorado

HEALTH DEPARTMENT OF CITY OF DENVER

By /s/ JAMES P. DIXON M.D.
Director, Bureau of Health & Hospitals
Denver, Colorado

COLORADO STATE DEPARTMENT OF HEALTH

By /s/ R. L. CLEERE
Secretary and Executive Officer
Denver, Colorado

PUBLIC HEALTH SERVICE

By /s/ GLEN J. HOPKINS
Officer in Charge, Missouri River
Basin Office, Kansas City, Missouri

SUPPLEMENT TO APPENDIX "A"

MEMORANDUM OF UNDERSTANDING

between

COLORADO GAME AND FISH COMMISSION
Denver, Colorado

and

COLORADO DEPARTMENT OF PUBLIC HEALTH
Denver, Colorado

WHEREAS, under the laws of the State of Colorado the Colorado Game and Fish Commission, hereinafter referred to as the Commission, is charged with the regulatory authority over all wildlife and fisheries resources wherever found within Colorado; and also holds legal responsibility in the control and abatement of stream and lake pollution as far as these resources are concerned, and is charged with certain regulatory authority to abate such pollution, and

WHEREAS, the Colorado Department of Public Health, hereinafter referred to as the Department of Public Health, also holds legal responsibility in the control and abatement of stream and lake pollution as far as public health is concerned, and is charged with regulatory authority to control and abate such pollution, and

WHEREAS, the U. S. Public Health Service, by Federal law, is cooperating with various Federal agencies, states and municipalities in the conduct of comprehensive studies of water pollution for the purpose of devising means by which such pollution can be abated or controlled, and

WHEREAS, as one of the cooperative projects, the Department of Public Health has entered into a cooperative arrangement with the U. S. Bureau of Reclamation, the U. S. Public Health Service and the City of Denver in the conduct of a comprehensive study of water pollution in the South Platte River Basin, and

WHEREAS, the Colorado Game and Fish Commission is desirous of cooperating with the Department of Public Health in the conduct of this study,

NOW THEREFORE THIS MEMORANDUM OF UNDERSTANDING WITNESSES:

The Commission agrees

1. To make available to the Department of Public Health and assign on the South Platte River Basin water pollution study two employees whose duties will be the collection of water samples, and whose salaries will

SUPPLEMENT TO APPENDIX "A"
(Continued)

be paid by the Game and Fish Commission subject to approval of the Governor of the State of Colorado and classification by the Colorado Civil Service Commission.

2. To make available to the Department of Public Health certain equipment as required for the proper conduct of the South Platte pollution study in an amount not to exceed a cost of $500, such equipment to remain the property of the Game and Fish Commission, with the understanding that it shall be returned to the Commission upon the completion of the water pollution study, or upon termination of this agreement.

The Department of Public Health agrees

1. To use the services of the two men and the equipment hereinbefore mentioned solely for the purposes as expressed under the terms of this agreement.

2. To report to the Commission all the facts and findings as a result of the survey to be made under the terms of this agreement.

3. To advise the Commission of any legal actions that may be possible or that may be initiated as a result of the aforementioned survey.

4. To invite representatives of the Commission to meet with the Department of Public Health as often as may be necessary regarding actions or plans in accordance with the purposes and the terms of this agreement.

5. To furnish the transportation and pay the subsistence and traveling expenses of the two men supplied by the Commission under the terms of this agreement.

It is mutually agreed by the Commission and the Department of Public Health

1. To cooperate in the formulation and the carrying out of adequate and practical plans as a guide for future programs for the control and abatement of stream and lake pollution.

2. To issue all necessary instructions through the Director of the Commission and through the Director of the Department of Public Health to all proper personnel of the Game and Fish Department and of the Department of Public Health respectively, covering meetings, investigations and field work needed for the preparation and subsequent administration of all the aforesaid plans or programs.

3. To require as close cooperation in the field, including the prompt and complete interchange of information, as is practicable by the proper personnel of the Game and Fish Department and of the Department of Public Health in all matters pertaining to stream and lake pollution.

SUPPLEMENT TO APPENDIX "A"

(Continued)

4. To scrupulously avoid, in the preparation of release and publicity material covering the abatement or control of stream or lake pollution in the State of Colorado any expressed or implied divergence of opinion by the Commission and the Department of Public Health; and endeavor to present a united front to the general public and to all especially interested parties.

5. That the Directors of the parties to this agreement will cooperate in all publicity questions of mutual interest, and will set up instructions to guide their subordinates in avoiding publicity of an overlaping character.

6. That it will be the responsibility of the Directors of the parties to this agreement to promptly and fully consider all complaints and suggestions and make adjustments if possible in accordance with the terms of this agreement.

7. That it is expressly stipulated and agreed to by both parties that each and every provision of this memorandum of understanding is subject to the laws of the State of Colorado and the laws of the United States.

8. Nothing in this agreement shall be construed as obligating the Commission or the Department of Public Health in the expenditure of funds for the future payment of money in excess of appropriations authorized by law.

9. That this agreement shall become effective as soon as signed by the parties hereto, and remain in force until terminated by mutual agreement or by either party upon ninety days (90 days) notice in writing to the other of their intentions to so do.

10. That amendments to this agreement may be proposed by either party and shall become effective upon approval by both parties.

Witness: /S/ R. M. Andrew Jr.

/S/ C. N. Feast
C. N. Feast, Director
Colorado Game and Fish Commission

Date: November 23, 1948

Witness: M. Canfield

/S/ R. L. Cleere
R. L. Cleere, Executive Director
Colorado Department of Public Health

Date: 11-23-48

APPENDIX "B"

SOUTH PLATTE RIVER BASIN
WATER POLLUTION INVESTIGATION

Stream Designations

Sampling stations for each creek are identified by the following symbols:

South Platte River	SP
Tarryall Creek	Ta
Trout Creek	Tr
N. Fork, S.Platte	SP-NF
Plum Creek	Pl
Bear Creek	Be
Turkey Creek	Be-Tu
Cherry Creek	Ch
Sand Creek	Sa
Clear Creek	Cl
St. Vrain Creek	SV
North St. Vrain	NSV
Middle St. Vrain	MSV
South St. Vrain	SSV
Boulder Creek	SV-Bo
South Boulder Creek	SV-SBo
Thompson River	T
Little Thompson	T-LT
Fall River	T-F
Buckhorn Creek	T-Bu
Cache LaPoudre River	CLP
North Fork	CLP-NF
Lone Pine Creek	CLP-NF-LoP

Cache LaPoudre (cont)	CLP
Boxelder Creek	CLP-Box
Lone Tree Creek	LoTr
Crow Creek	Cr
Little Crow	Cr-LC
Coal Creek	Cr-Co
Boxelder Creek	Box
Kiowa Creek	K
Commanche	K-Com
Bijou Creek	Bi
West Bijou Creek	Bi-WF
Cat Creek	Ca
Badger Creek	Ba
Beaver Creek	Bea
Spring Creek	Sp
Rush Creek	R
Lewis Creek	Le
Cottonwood Creek	Cot
Lodgepole Creek	Lod
South Fork	Lod-SF
Mud Creek	Lod-Mu
Cow Creek	Lod-Cow
Wabrath Creek	W

Tributaries of creeks follow the designation of the main stem designation, viz., Lone Pine Creek, which is a tributary of the North Fork of the Cache LaPoudre River, would be CLP-NF-LoP.

APPENDIX "C"

STREAM POLLUTION SURVEY OF THE PORTIONS OF THE SOUTH PLATTE RIVER AND CHERRY CREEK WHICH LIE WITHIN THE CITY AND COUNTY OF DENVER*

Section I

On September 3, 1948, a stream pollution survey of that portion of the South Platte River and Cherry Creek which lies within the city limits of Denver was commenced by the Sanitation Division of the Bureau of Health and Hospitals. This survey was made in cooperation with the United States Public Health Service and the Colorado Department of Public Health as a part of the South Platte River Pollution Survey now being conducted by those agencies. The purpose of this survey was to determine those industries which contribute liquid waste materials to either of these streams aid if possible, to discover the approximate quantity and content of the waste. The survey was confined to field surveys of the various industries and the results were entered on a generalized industrial waste form. No stream samples were taken, waste flow was not gauged, nor was any remedial action taken.

Over a period of two months, seventy-two business establishments were checked and inspection forms filled out on thirty-two of these. The remainder were eliminated from consideration as field inspections and questioning of the management revealed that they contributed nothing to the pollution in the river. No report sheets were filled out on the establishments.

A summary of the survey findings of the thirty-two establishments follows:

Establishment	Date Surveyed	Quantity of Waste Contributed to River (gpd)	Nature of Waste
Swift Packing Company	9 -20-48	None*	
Armour Packing Company	9- 21-48	None	
Cudahy Packing Company	9 -14-48	None	
Capitol Packing Company	9 - 8-48	165,000	Cooling Water
Landers Packing Company	9- 7-48	None	
Adams Packing Company	9 -13-48	100,000	Washings from Gut Room Large Amounts of Paunch Manure
Pepper Packing Company	9 - 9-48	Unknown**	Blood, Paunch Manure**
K & B Packing Company	9 - 9-48	None	
Denver Union Stockyards	9 -21-48	No Estimate Available	Wash water from pans contain grains, hay,manure, etc.
Union Rendering Company	9- 20-48	None	(Have line to river--sealed and locked)
Jada Sudsation	9 -27-48	None	

*City and County of Denver are one and the same.

APPENDIX "B" (Continued)

Establishment	Date Surveyed	Quantity of Waste Contributed to River (gpd)	Nature of Waste
Colorado & Southern Roundhouse	9 -27-48 9 -28-48	No Estimate Available	Wash water--small quantity oil and grease
Denver Iron Works	9 -28-48	None	
Public Service-Lacombe Addition	9 -28-48	44,000,000	Cooling Water
Acetylene Service Co.	9 -29-48	6,000	Water and Lime Mixture Lime deposited in river
Maddox Ice Company	10-15-48	252,000	Cooling Water
D & R G Roundhouse	10-13-48	No Estimate Available	Wash water--oil, grease, some acid and lye
Maul's Rug Cleaning Co.	10 -5-48	No Estimate Available	Soapy wash water from cleaning carpets
Bud's Rug Cleaning Co.	10 -5-48	No Estimate Available	Soapy wash water from cleaning rugs
General Chemical Co.	10-15-48	800,000	Mostly cooling water Some acid waste, small quantity of Iron Oxide
U. P. Roundhouse	10-25-48	None	
Burlington Roundhouse	10 -5-48	No Estimate Available	Wash water--oil and grease
Shattuck Chemical Co.	10 -4-48	-----------	
Gates Rubber Company	10-25-48	432,000	Cooling water with small amount of wash water
Tramway Power House	9 -14-48	7,440,000	Cooling water
American Smelting and Refining Company	10 -5-48	None***	
Cambridge Dairy	9 - 3-48	No Estimate Available	Wash water from barns Some straw, manure, etc.
Merchant's Extract Co.	9 - 3-48	None	
Mil Producers	9 - 7-48	None	
Canada Dry Bottling Co.	9 -17-48	None	
Carlson Frink Dairy	9 -17-48	None	
Police Garage	9 - 7-48	None	
City Dump--31st and Sand	--------	No Estimate Available	Organic in nature due to decaying matter
Denver Sewage Treatment Plant	9 -19-48	-----------	Primary treated sewage

*Swift Packing Plant has line running to river but this is closed off.

**This plant is now working on plans to screen their waste material and pump all waste into city sewerage system.

***Overflow effluent from cess pools serving two small toilet rooms discharges into irrigation ditch. The Denver Health Department has ordered this discontinued and company has planned to install new septic tanks and leaching wells or connect to city sewer, if possible.

APPENDIX "C" (Continued)

Section II

RAILROAD REPAIR SHOPS SURVEYED

Four railroad repair shops were surveyed and three of these were found to be contributing unestimated quantities of oily waste to the river. The three companies involved are: Burlington Roundhouse, Denver and Rio Grande Western Roundhouse, and the Colorado and Southern Roundhouse. The Burlington and D & R G have no treatment whatsoever, but the Colorado and Southern Roundhouse has a series of detention basins to recover as much oil and grease as possible.

The effects of the oily waste are evidenced along the river bank by deposits of grease and by the oil slick on the water. The slick is very pronounced for some distance down the river and although less evident, can be seen quite easily for a distance of one-half mile or more below the outlet.

SECTION III

MEAT PACKING PLANTS AND STOCKYARDS

There are eight meat packing houses within the city limits of Denver, of which six are United States Government inspected. Most of the plants maintain their own rendering plants and the general plant sewerage system.

A stockyard association provides stockpens for the three largest meat packing plants but the five smaller companies maintain their own pens, etc.

The total waste from the packing houses, stockyards, and rendering plants amounts to approximately 4,040,500 gallons per day. About 62,000 gallons of this is discharged into the river, the remainder to the city sewage disposal plant. A further breakdown of the discharge to the river shows that approximately 40,000 gallons is cooling water, roof and land drainage, and general storm run-off. An estimated 2,000 gallons is water used by the stockyards to flush stand-by lines from stock pens to prevent silting. Some grain, straw, and manure particles are carried in this water and deposited along the river banks. The remaining 20,000 gallons is discharged from the gut room of the Adams Packing Company and contains much paunch manure and other typical waste material from this process. Considerable deposition of manure is evident along the bank of the river and the finer particles of waste are carried some distance down the river by the current. Since the general character of the river water is muddy and turbid, it is difficult to determine to what extent the waste manure is dispersed and carried along with the river flow.

At the time of the original survey, Pepper Packing Company was not found to be discharging wastes into the river. However, during subsequent investigations in that area, considerable quantities of blood, paunch manure, and similar wastes were found running from a drain to the river.

This was eliminated and no changes made in the original survey report. Similar occurrences were noted later but due to the fact that Pepper Packing Company is cooperating with the Health Department in an effort to eliminate the problem, no changes have been noted on the survey report of this establishment.

Section IV

DUMPS AND DUMPING

City Dump at 31st and Sand

The city-operated dump is in a flooded abandoned sand pit at 31st and Sand Street. Recently a culvert was put in between the pit and the South Platte River to drain the pit. It is difficult to estimate the quantity of waste discharged through this culvert. The waste is organic in nature, and only partially decayed thus contributing an appreciable quantity of putrescible material to the river.

Unauthorized dumping in Cherry Creek

The section of Cherry Creek between Blake Street and the junction of Cherry Creek with the South Platte River has apparently been used as a dump by many small business establishments in that vicinity. This part of the creek is littered with cans, bottles, cardboard cartons, papers, and other types of trash. It is very difficult to determine the source of this material since it is very general in extent and nature. The degree of pollution contributed by this material is also indeterminate but undoubtedly does have some effect on the quality of the water (in addition to creating an unsightly appearance).

City of Denver Sewage Treatment Plant

At the present time the City of Denver is contributing approximately 60,000,000 gallons of partially treated sewage to the South Platte River. Plans for doubling the size of the primary treatment equipment have been completed and revenue bonds have been sold for the financing of this construction. These plans include the construction of two new sections of bar screen, one new grit chamber, two new aeration tanks, two clarifiers, two digesters, and one fine screen for final effluent; plans also include the doubling of the present laboratory space. The estimated cost of such construction is $1,750,000. Tentative plans are underway for an additional bond issue to finance the construction of complete treatment facilities.

APPENDIX "C" (Continued)

Section V

GENERAL SUMMARY AND CONCLUSIONS

The amount of pollution contributed to the South Platte River and Cherry Creek by industries in the city of Denver is relatively low. The greater part of wastes returned or disposed of in the river is cooling water and the effect is one of temperature rise rather than outright pollution. The most serious types of pollutant found in the river in Denver are oil and grease from railroad roundhouses. Packing plants, for the most part, discharge their waste material into the city sewers and are, therefore, not responsible for any subsequent pollution. The single plant which is now discharging paunch manure into the river will be assisted in corrective measures in the near future.

Only two cases of chemical pollution were found and they were not considered to be of a very serious nature. The lime discharged by an acetylene producing plant creates a problem of deposition while the discharge from the other plant actually contains very small amounts of acid.

The remaining pollution material is due to the drain from the city-operated dump and indiscriminate use of drainage ditches and the river as dumps by individuals. The degree of pollution is difficult to estimate, but must be considered in the over-all picture of the problem.

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DISPOSAL OF BEET SUGAR WASTES

Review of Literature

I Abstract

Beet sugar is extracted when warm water is passed over sliced beets. Raw sugar is crystallized out of the resulting solution.

The four major factory wastes are:

1) Flume water used to clean and transport beets

2) Process water from drainage of pressed beet pulp and from sugar extraction battery cell (diffuser) washings

3) Lime slurry from the juice filters

4) Steffens waste, the residue from the recovery of sugar from molasses.

The wastes vary in strength from Steffens waste having a five day 20°C. biochemical oxygen demand of 10,000 ppm to flume water having a biochemical oxygen demand of 200 ppm. The medium strong wastes, process water and lime water, have a biochemical oxygen demand of 1250 ppm and 1750 ppm respectively.

The waste flow per ton of beets totals about 3100 gallons and consists of (a) 72.1% flume water, (b) 21.6% process water, (c) 2.4% lime drainage, and (d) 3.9% Steffens waste. Plant capacities vary from 600 to 2000 tons of beets processed per day.

In many instances wastes are disposed of by simple dilution in surface streams. Pollution abatement measures which may be applicable are treatment, re-use of water, process water discharge elimination and utilization of Steffens waste.

By-products are beet pulp, filter press cake and molasses.

II Statement of Problem

The problem is complicated. The volume of beet sugar wastes is large and the concentration of organic solids is high. The different points in the process produce wastes of widely variable characteristics. These wastes require different kinds and different degrees of treatment; therefore, it is logical that these wastes be treated separately. However, treatment of day to day wastes would be expensive especially in view of the high fixed plant charges on facilities lying idle except for a 100 day season.

Proper application of the principle of re-use can result in correction of pollution and solution of water supply problems. Re-use can also result in improved heat economy and a higher per cent of sugar and solids recovery. Coupled with these advantages are three serious disadvantages. Re-used water contains an ever-increasing amount of organic acids produced by fermentation of organic matter. Re-circulation increases the intensity of corrosion of equipment. Lastly, re-use of waste waters in the beet sugar industry endangers the quality of the product.

Elimination of the process water discharge by use of a continuous counter current sugar extractor (diffuser) may also produce a detrimental effect on the product.

Steffens waste can be evaporated and the resulting residue sold for fertilizer. This is efficient but at present it is costly.

A new waste treatment angle is a method of bleeding off lagooned wastes for treatment in a trickling filter over a year's period. This gradual treatment reduces the size of the plant required. The odor problem is aggravated by the long term lagooning, however.

Pollution abatement measures are usually essential, for beet sugar wastes cause color and odors in the receiving streams and place a high oxygen demand on the streams. The population equivalent of beet sugar wastes produced in the United States last year was between 7,100,000 and 12,400,000 per day.*

In summary, correction possibilities include: a) a combination of treatment and re-use; b) total re-use; c) total re-use with periodic bleeding off of water having a high solids content; d) gradual treatment of lagooned wastes; e) use of a continuous diffuser; or f) evaporation of Steffens waste.

III Process

1. Description of Process[1]

Beet sugar manufacture is seasonal since there is no satisfactory method of storing beets for long periods of time. The factories run 24 hours a day for about 100 days mainly in the months of October to January.

Beet sugar extraction follows about the same procedure all over the country. The sugar is obtained from two operations called straight house operation and Steffens house operation. Sugar is extracted until a heavy molasses is formed in the straight house. The molasses is processed for further recovery in the Steffens house.

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*This is the range for waste equivalent from the straight house process and the combination straight house-Steffens house process.

The beets are delivered to the factory and unloaded into storage silos mechanically or by aid of jets of water. They are transported to the straight house by water flowing in flumes and are passed through a washing machine. The beets are then sliced and placed in sugar extraction cells or diffusers. Using a counter-flow principle, warm water enters the diffuser containing the most nearly exhausted slices and passes continuously through the remaining cells. Exhausted pulp containing about 0.2% sugar based on the weight of the beets is discharged, drained, press dried and marketed. Impurities in the juice (mostly colloidal) are removed in two operations: addition of lime precipitates some of the colloids; remaining impurities are removed by the precipitate of calcium carbonate formed when carbon dioxide is added to the lime treated juice. The carbon dioxide is added in two doses and the juice is filtered after each dose. The "lime cake" is discharged as waste. The resulting clear, yellow juice is bleached with sulfur dioxide (SO_2) gas and filtered. The SO_2 also serves to precipitate any remaining lime. Multiple effect evaporators remove the water from the purified juice. The syrup from the evaporators is crystallized in vacuum pans. The crystals are separated from the mother liquor by centrifugal action. The product of this treatment contains 95-98% sucrose and about one per cent water. The mother liquor from the centrifuge is returned to the vacuum pans. The liquor from the pans is centrifuged and second grade crystals are produced. The mother liquor from which no more sucrose can be crystallized profitably is called molasses. This residue is sold or further treated for recovery in the Steffens house.

The Steffens process consists of diluting the molasses to a definite concentration and treating it with lime so that tri-calcium sucrate precipitates. The sucrate is filtered out and the sugar is recovered by adding CO_2. The precipitated $CaCO_3$ is removed by filtration. The filtrate is evaporated and the sugar is crystallized out in the straight house.

2. Raw Materials and Products

a. Raw Materials

Raw materials consist of:

1) Sugar beets, about 7.5 lbs. per lb. sugar.

2) Lime (CaO) about 4.5 lbs. per 1000 gallons of process water (equals about 2.8 lbs. per ton of beets). If the flume sludge is vacuum filtered 50-80 lbs. of lime are added per 1000 gallons of flume sludge.

3) Sulfuric acid, about 4 lbs. per ton of beets. (As used in Swedish method of re-use.)

4) Sulfur dioxide, small amount for bleaching sugar.

5) Carbon dioxide, minimum of 3.6 lbs. per 1000 gallons of process water.

b. Products

There are 100 beet sugar factories in the United States located near beet farms in 17 States. These factories provide about 25% of the sugar used annually in the United States. The total annual production for the year 1948 was 1,316,000 tons. The production per factory varies from 90 to 300 tons per day during the campaign. The U. S. Sec. of Agriculture allocated a quota of 1,800,000 tons of domestic beet sugar for 1949.[32]

IV Wastes

1. Sources and Quantity of Wastes[1,22]

The average volume of waste water per ton of beets is about 3,100 gallons. The quantity of flow is an influential factor in processing sugar so flow data are reasonably accurate. Flume water constitutes 72.1% of the flow, 21.6% is process water, 2.4% is lime drainage and 3.9% is Steffens waste. The volume of condenser water per ton of beets is about equal to the volume of flume water used. Condenser water is not an important factor in waste treatment. It can be re-used after merely cooling it and in some cases disinfecting it with chlorine. There is a small amount of concentrated drainage from the storage silos that might escape into surface waters. No mention of treatment methods for this waste was found in the literature examined.

Sugar beets contain about 15% sugar by weight; of this 15%, 0.6% is lost in the straight house and 0.24% is lost in the Steffens house. Other solids constitute 9.8% of the weight of the sugar beet. Of this 9.8%, 3.8% is lost thru factory wastes. Therefore, about 4.6% of the solids weight of the beet is lost thru factory wastes. These data are based on analyses of the clean beet.[1]

2. Character of Wastes

The composition and comparison of beet sugar factory wastes are shown in tables one and two.[1]

TABLE I - Composition of Beet-Sugar-Factory Wastes

	Flume Water	Process Water	Lime-cake Drainage	Steffens Waste
Volume (gal.) (per ton of beets)	2200	660	75	120
5-day B.O.D. p.p.m.	200	1230	1420	10000
Total solids, p.p.m.	1580	2220	3310	43600
Suspended solids, p.p.m.	800	1100	450	700
Dissolved solids, p.p.m.	780	1120	2850	42900

TABLE 2 - Comparison of Wastes (Per ton of beets)

Waste	Volume		B.O.D.		Population Equivalent
	Gal. per day	%	Lb. per day	%	
Flume Water	2200	72.1	3.70	17.6	22
Process Water	660	21.6	6.77	31.7	40
Lime Drainage	75	2.4	.70	3.4	4
Steffens	120	3.9	10.01	47.3	60
Total	3055	100.0	21.18	100.0	126

The solids content varies in amount and quality in the waste waters. Flume water is used to clean and transport beets; it contains beet tops and roots, leaves, stones, sand, silt and a small amount of sugar. Process water consists of drainage from pressed beet pulp and from battery cell washings; it contains finely divided pulp in suspension, organic matter in colloidal suspension and a comparatively large amount of sugar and other organic matter in solution. Lime slurry from the filters consists mainly of calcium carbonate but it is also contaminated with many organic and inorganic impurities removed from the juices (such as alkali oxalates and phosphates). Steffens waste, the residue from the recovery of sugar from molasses, contains 3 to 5% solids composed of a large variety of organic and inorganic substances.

3. Disposal of Wastes

The methods of waste disposal used in the United States and in foreign countries have met with varying success. The difference in the economic standards of the United States and most foreign countries is an important factor in considering adaption of foreign methods in this country.

a. Treatment

1) Eldridge[1]

Eldridge discusses treatment at some length in his book. He recommends separation and treatment of the individual wastes. The methods used and the results in terms of removal of suspended solids and B.O.D. are tabulated in Table 3.

TABLE 3 - Efficiency of Treatment Process

Process	Suspended solids removal, per cent	B.O.D. Removal per cent
Plain settling of flume water	92.1	42.1
Coagulation of process water	93.4	47.4
Coagulation with **Steffens**	93.7	51.6
Biological filtration of process water	-	80.0

Design factors are enumerated in Table 4. The design figure is based on capacity requirements of a plant processing 1000 tons of beets per day.

TABLE 4

Design Factors in Treatment Plant Based on Capacity Requirements of a Sugar Plant Processing 1000 Tons of Beets per Day[1]

Type of Treatment	Design Factor Considered	Design Capacity Requirement
Flume Water		
1. Screening	Capacity of screen (Basis: Maximum flow)	1 sq.ft/800 gal./hr.
2. Grit Removal	Accumulation in grit chamber	8-15 cu.yd./ 1,000,000 gal. waste flow
3. Settling	Capacity of settling tank (Detention time: 80 min.)	16,300 cu.ft.
Process Water		
1. Coagulation	Capacity of coagulation tank	1,570 cu. ft.
2. Settling	Capacity of settling tank (Detention time: 2 hrs.)	7,200 cu. ft.
Sludge Disposal		
Ponding	Capacity of sludge ponds (total)	293,000 cu. ft.
Lime Slurry		
Concentration	Capacity of concentration tank (Detention time: 2 hrs.)	830 cu. ft.

The treatment of the separate wastes as outlined by Eldridge is described under the headings Flume Water, Process Water, Sludge Disposal, Lime Slurry, and Steffens Waste, and Biological Filtration.

Flume Water:

Flume water requires screening, grit removal, rapid sedimentation, and quick removal of sediment.

Screens must be designed for maximum flow since the capacity is affected by surges of the flume water. Screens are of two types, drag and rotary. Screenings are removed to the screen platform by a screw conveyor.

Use of a grit chamber cuts down on the amount of thick sludge in the sedimentation tank. There must be continuous removal of the contents of the chamber. The contents are dry enough to be transported without further treatment.

Rectangular or circular settling tanks of the continuous sludge removal type are recommended.

Process Water:

Process water quick coagulation and settling are accomplished with the use of a lime feed machine, a mixing trough, a coagulation tank and a sedimentation tank.

The rate of flow of process water is fairly constant so the lime feed machine can be set to deliver at a constant rate. (Use of 4.5 lbs. of lime per 1000 gallons waste is recommended.)

The lime and process water are mixed in a sloping concrete trough before the waste enters the coagulation tanks.

Paddles in the coagulation tank keep the solids in suspension. The velocity of movement is kept between 60 and 120 feet per minute; in this range the material is kept suspended but the floc is not broken up.

The settling tank is similar to that used for flume water.

Sludge Disposal:

Sludge can be disposed of by ponding or by vacuum filtration.

Ponds must be large enough to hold the entire sludge volume produced in a season. Decomposition of organic solids gives rise to a strong effluent that presents a serious pollution hazard if its escape is not carefully controlled.

Vacuum filtration produces cake of about 50% moisture. Flume water sludge must be conditioned with lime before filtration. The rate of filtration averages about 100 gallons per square foot per hour. Filtrate is returned to the process water and passed through the coagulation process again. The sludge cake is sold as fertilizer.

Lime Slurry:

Lime cake is commonly washed off the filter and stored. This is generally unsatisfactory; drainage is highly polluting and maintenance of maximum efficiency demands that the storage facilities be cleaned frequently. It is preferable to remove the cake from the presses in a comparatively dry form and transfer it by means of an endless belt or a slurry pump. If the cake must be washed out of the dryers it can be concentrated in a tank and filtered on a vacuum filter. Rate of filtration is about 100 gallons per square foot of filter per 24 hours.

Steffens Waste:

Steffens waste can be disposed of by mixing it with other wastes, in which case it serves as a coagulant, or by evaporating it and utilizing the residue.

It is reported that 4% Steffens waste mixed with 96% combined wastes produces a floc heavier than the floc produced by lime. The detention time in the coagulating tank is 20 minutes and the detention time in the sedimentation tank is 90 minutes for the average rate of flow of the combined wastes.

It is possible to dry the Steffens waste using multiple effect evaporators or spray drying equipment. These methods are as yet too expensive for practical use. For a discussion of recovery of by-products from Steffens waste see section titled "By-Products".

Biological Filtration:

The average B.O.D. of the effluent after coagulation and sedimentation of process water is about 660 ppm. The organic matter producing the B.O.D. (mostly sucrose) may be removed by biological oxidation. It takes 3 to 5 weeks to develop the bacterial flora on the filter. Furthermore, the growth of these bacteria is made difficult by the low temperatures usually prevailing during the campaign. The cost of installation of the filter is high. These factors make the use of bacterial filters impracticable under most circumstances.

2) British

A new treatment procedure is being developed in Britain. The wastes are lagooned and bled into surface waters over the year after treatment in a trickling filter. This method requires a relatively small treatment plant. The literature does not comment on the odor problem that would certainly accompany such a plan.

b. Re-Use

The principle of re-use appears to be applied more successfully in foreign countries than in the United States. This is possibly due to differences in the basic economies of those foreign countries. It is also true that these foreign industries can profit using methods that would be extremely costly to the United States industry.

1) Wintzell-Lauritzson Process[6,7]

The most successful method of re-use cited in literature is the Wintzell-Lauritzson process. This method is being used in Sweden with reported noticeable increase in sugar and solids recovery and better heat economy in the factories. Corrosion, a major factor in re-use, is retarded by acidification of the re-use waters and by using a closed airtight system. Foaming is reduced by designing the flow so that pumping is kept at a minimum. The procedure for re-using the process waste water (diffusion waste plus pulp press water) is as follows.

Diffusion Water:

Diffusion waste water is redelivered after mechanical purification in a sand catcher and in a Babrowski filter (a rotary drum of metal gauze).

Pulp Press Water:

Pulp press water receives the same mechanical treatment plus precipitation of colloids by acidification to a pH of about 3.2 with sulfuric acid. The colloids are concentrated in 10% of the water by lamellar decantation. Further separation is accomplished in a centrifuge. The concentrate is stirred with molasses and sent to the drying room to dry on beet pulp. The purified water is returned to the diffusion process.

According to these Swedish authorities, re-use does not produce any bad effects on battery operation.

2) Danish Method[21]

A method of recirculation after disinfecting process water with hypochlorous acid is being experimented on in Denmark.

3) Buckeye Sugar Company Method[2]

The Buckeye Sugar Company in Ohio has had reasonable success during the past ten years re-using process water in the juice extraction process. Many factories in the United States re-use process water to wash out the beet pulp and re-use of flume water is generally practiced, especially in the eastern factories. The Buckeye is the only United States factory that has a method of re-utilization that approaches a closed system. The method is described in the following paragraphs:

Flume Circuit:

The flume water is chlorinated, screened and settled. The screen is a drag type unit with 1/32 inch slotted openings. A detention time of 30 minutes is provided for in the settling tank. An emergency overflow must be provided for overflow caused by surges of the flume water.

Process Water Circuit:

The process water is treated in Babrowski filters. The effluent is sent to a baffled, cylindrical, conical bottomed reaction and clarification tank. Milk of lime is added for coagulation and clarification. The treated water is stored for use in the diffusion battery at 65° C. to prevent fermentation. The lime sludge is drawn to the lime sludge system.

The factory has not had trouble with organic build up in the re-used waters. The 1941 operation indicated a B.O.D. population equivalent reduction of 79%, a volatile solids reduction of 80% and a suspended solids reduction of 99% over operation without re-use. This study is limited so these data should not be accepted as the final word on this subject.

c. Process Water Discharge Elimination

Elimination of process water discharge is accomplished by use of a continuous diffuser. Water and beets flow countercurrent to each other in a single long diffuser. The press water is returned to the diffuser. The English Raabe Continuous Diffuser is the best known equipment of this type. It is less efficient and more costly than the fill and draw type. The juice is also inferior.

A new, smaller, cheaper, simpler continuous diffuser, the Oliver Morton diffuser, was tried out in the 1948 campaign and judged the equal in performance and operating efficiency to the large-scale continuous diffuser with which it was being compared.[31]

V By-Products

By-products from the sugar beet industry are beet pulp, lime cake, molasses and Steffens waste.

Pressed beet pulp is generally sold and used as cattle food.[3,4] Efficient storage increases the food value.[5]

Lime cake is a good fertilizer for beet farmland.[8] It is sold wet or dry.[9] Foreign reports[8,10,11] state that the cake can also be used for cattle food. Omission or modification of the main liming makes a cake high in organic substances. Experiments have been made on re-use of the burned cake for initial liming.[12,13] Results are poor. The load is too great on the filter presses. The maximum number of regenerations feasible was found to be three. It is economically practical to process the cake for use as a filter aid and for use as activated carbon in India.[14,15]

Molasses may be fermented to yield alcohol[16] or used in the manufacture of cattle food[17] or purified to make edible syrup.[18] It can also be fermented and burned to obtain its potash content.[19,20] Steffens waste cen be evaporated and the crystallized solids can be sold for fertilizer.

Investment in by-products is determined by the economics of the country. It might be practical in the United States to sell beet pulp as cattle food, lime cake as fertilizer and molasses for fermentation purposes. The other refinements are at present limited to foreign countries where scarcity of the products gives them a higher value.

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APPENDIX "E"

STATE WATER POLLUTION CONTROL LEGISLATION

(Outline prepared by Office of the General Counsel, Federal Security Agency, in consultation with the Division of Water Pollution Control of the Public Health Service - February - 1949.)

PRELIMINARY STATEMENT

The greatest State legislative activity in the field of water pollution in the history of this country has occurred in the past decade. About half the States have passed new laws or amended their old statutes within this period. Since this type of legislation has been concentrated within a relatively recent period, it is not surprising to find a marked similarity in the enactments. In general, they have followed the technique of setting up an administrative agency to deal with the problem of water pollution control. Legally, the problem is largely a specialized application of the principles of administrative law.

It is characteristic of State water pollution control legislation to set up a body of statutory and administrative law superimposed on the common law remedies of private parties. The older State legislation was marked by a piecemeal lodging of concurrent water control statutory authority within several departments of the State, such as those dealing with health, agriculture, fish and wild life, and mines and minerals. The modern tendency is to coordinate all State water pollution control activity under a single administrative agency.

As in most cases where the administrative law approach has been applied, the efficacy of a particular program depends on many extra-legal elements such as administrative personnel, size of appropriation, and public understanding.

The following is an outline of component parts, with suggested criteria, for a State statute for the purpose of establishing and carrying out a program for water pollution prevention and control. This outline will be further developed from time to time on the basis of continued study, consultations and experience.

STATEMENT OF POLICY

A declaration of State policy in the statute is desirable. Such a declaration indicates the basic objectives which are to guide the State agency in the exercise of authority delegated to it by the legislature and is an aid to the administrative agency and the courts in the interpretation of the statue. Such a statement might read:

> "Whereas the increase in pollution of the waters of this State, due to the growth of population and industrial activities, constitutes a menace to health and welfare

> threatens the extinction of fish and aquatic life, and progressively obstructs agricultural, industrial, recreational, and other legitimate uses of water, and whereas the problem of water pollution in this State is closely related to the problem of water pollution in adjoining States, it is hereby declared to be the public policy of this State to conserve the waters of the State for public water supplies, for the propagation of fish and aquatic life, and for agricultural, industrial, recreational and other legitimate uses, to provide a comprehensive program in the public interest for the prevention, abatement, and control of pollution, to provide effective means for the carrying out and enforcement of such program, and to provide for cooperation with agencies of other States and of the Federal Government in carrying out these objectives."

ADMINISTRATIVE AGENCY

1. Administrative authority and responsibility should be vested in a single State agency with comprehensive powers. There should be no exemption of particular municipalities, areas or industries from the jurisdiction of the agency.

> Such a single State agency, charged with comprehensive power and responsibility for carrying out State laws relating to water pollution abatement, would constitute the "State water pollution agency" for purposes of recognition as such under the Federal Water Pollution Control Act. See Sec. 10 (a).

2. The State agency might be:

   (1) a single administrator,

   (2) a commission, with members appointed by the Governor, or

   (3) an ex-officio board, composed of heads of State departments having related responsibilities, such as health, conservation, agriculture, etc., or

   (4) variations of the above.

3. Establishment of the agency in the State health department is recommended. If the agency is of the board or commission type the State health officer should be a member.

4. If the agency is to be an ex-officio board, it may be desirable to fix by statute a minimum number of meetings per year.

5. Provision should be made for an executive officer, and there should be authority for the appointment of personnel, including consultants and hearing officers. The merit system should be applicable to personnel of the agency.

6. The agency should be authorized to utilize the personnel and facilities of other State agencies and to make reimbursement therefor.

7. It may be desirable to authorize delegations of authority to subordinate officials, excepting, however, in such matters as the adoption of rules and regulations, comprehensive programs and standards of water purity, the classification of waters, and the issuance of orders or making of any final determination which directly affects the activities or interests of any person or group.

ADVISORY FUNCTIONS

If the agency is of a single-administrator type, a supplementary council with purely advisory functions may be a useful adjunct; such a council may be composed of representatives of other State departments having related responsibilities or (like the Water Pollution Control Advisory Board in the Public Health Service) be expanded to include a limited number of persons (appointed for limited terms) representative of particular fields of expert knowledge, public and private interests. For other types, the value of a statutory advisory council is likely to be less, but the agency should in any case have authority to advise and consult with interested and affected groups. (See "Powers and Duties").

POWERS AND DUTIES

The water pollution agency should have the following powers and duties:

1. To develop a comprehensive program for the prevention, control and abatement of water pollution throughout the entire State;

2. To advise, consult, and cooperate with other agencies of the State, other States and the Federal Government and with affected groups and industries, in the formulation and carrying out of such a program; to accept and administer loans and grants from the Federal Government and from other sources for carrying out any of its functions;

3. To encourage and conduct studies, investigations, research and demonstrations (with specific mention of industrial waste problems); to collect and disseminate information relating to water pollution and the prevention, control and abatement thereof;

4. To set standards of water purity and classify waters according to their particular uses;

5. To adopt, after hearing, general rules and regulations pertaining to the prevention, abatement and control of water pollution. For example, such rules and regulations might require, among other things, that permits for the operation of treatment works be obtained in certain cases in which they would not otherwise be mandatory under the statute. (See below under "Enforcement" for those cases in which permits should be required by the statute.) They might also establish standards for the operation of disposal systems and treatment works.

6. To issue, after hearing, orders abating discharges or requiring the adoption of such remedial measures, including the construction of new disposal systems or treatment works or the modification, extension or alteration of existing systems and works, as the agency deems necessary or proper; to receive complaints and make investigations in connection with the foregoing;

7. To examine and pass upon all plans and specifications for, and to inspect the construction of (a) new disposal systems and treatment works, (b) extensions, modifications or additions to new or existing disposal systems or treatment works, and (c) extensions and modifications or additions to factories, manufacturing establishments or business enterprises, the operation of which would cause a substantial increase in the pollutional load. (See below under "Enforcement" for suggestion that approval of plans and specifications be required for construction of certain disposal systems and treatment works);

8. To issue, continue in effect, revoke, modify or deny permits, under such conditions as it may prescribe, for the discharge of any wastes, and for the installation and operation of disposal systems and treatment works. (See below under "Enforcement" for suggestion that permits be required for waste discharges);

9. To take all action necessary or appropriate to secure to the State the benefits of the Federal Water Pollution Control Act (Public Law 845, 80th Congress; 62 Stat. 1155). (See the draft Water Pollution Control Enabling Act for specific functions which would be involved in so doing; it is not suggested that these be spelled out in a comprehensive water pollution control statute except to the extent that legal authorities of the State may consider specification necessary. This draft act was proposed by the Council of State Governments as part of its 1949 legislative program. Copies of the draft act were submitted by the Council directly to the States.)

ENFORCEMENT

It is suggested that the water pollution control law contain enforcement provisions along the following lines:

1. Sanctions against pollution

(a) Prohibit discharge of any wastes from any disposal system or treatment works constructed or operated

APPENDIX "E" (Continued)

(i) without a permit from the agency in cases where a permit is required by the statute (see below) or by the rules, regulations or orders of the agency, or (ii) in contravention of the terms of a permit or of the rules, regulations or orders of the agency;

(b) (i) As to new disposal systems and treatment works, plans and specifications should be required to be submitted and approved and permits issued by the agency as prerequisites to their initial construction and operation, as well as to the construction and operation of any extensions, modifications or additions thereto;

(ii) As to existing disposal systems and treatment works, plans and specifications should be required to be submitted and approved and permits issued by the agency as prerequisites to the construction and operation of any extensions, modifications and additions thereto. (See paragraph 5 of "Powers and Duties" above for authority of agency to require, by rule or regulation, that permits be obtained for the continued operation of existing systems or works);

(iii) The submittal of plans and specifications and the issuance of permits should be required for the construction of extensions, modifications, or additions to manufacturing establishments or business enterprises, the operation of which would cause a substantial increase in waste discharges.

(c) Prohibit performance of any act which causes or which may tend to cause pollution in contravention of the standards of water purity adopted by the agency or which is in violation of the rules, regulations or orders of the agency.

(d) Violation of prohibitions in (a), (b), and (c) above punishable by fine, or by fine and/or imprisonment. Statute might also provide for criminal liability of officers and directors of corporation for violations by the corporation.

(e) Each day on which a violation occurs deemed a separate and additional violation.

2. Investigations. The agency should have the power to enter at reasonable times upon any private or public property for the purpose of inspecting and investigating conditions which contribute, or threaten

to contribute, to the pollution of any waters.

3. Hearings

(a) The agency should be required to grant a hearing before any rules or regulations of general applicability are adopted which pertain to the prevention, abatement or control of water pollution (e.g., regulations setting standards for the operation of disposal systems and treatment works), or before any order is issued by the agency (e.g., order prohibiting respondent from discharging wastes), or before any other final determination is made (e.g.,revocation, modification, etc., of a permit) which directly affects the activities or interests of any person or group. Provision may be made for summary procedures in emergencies involving hazards of an imminent nature.

(b) The agency should have necessary incidental powers such as the power to compel the attendance of witnesses and the production of testimony, to administer oaths, and examine witnesses.

(c) Safeguards should be provided such as the requirements of (i) seasonal notice, including publication thereof in the event that the proposed proceedings affect a group or groups of individuals, (ii) opportunity of respondents to file answers, and (iii) opportunity of respondents to be represented at counsel at the hearing. (Such safeguards may be spelled out in the statute or provided for by regulation.)

4. Legal action

(a) The agency should be empowered to bring action to enjoin violation of law or of its rules, regulations or orders.

(b) The Attorney General of the State may be required to bring civil or criminal action on the request of the agency to enjoin or punish violations.

5. Judicial review. Judicial review of all final orders of the agency should be provided.

DEFINITIONS

A definition section is an integral part of a comprehensive water pollution control statute. As the purpose of a definition section is to implement the administration and interpretation of the statute, care should be taken to avoid either unduly restrictive or vague definitions.

Terms for which definitions are usually desirable are "sewage", "industrial wastes", "other wastes", "pollution", "sewerage system", "treatment works", "disposal system", "waters of the State", and "persons". While there do not seem to be significant differences among the several States in definitions of the same or similar terms, several caveats are offered:

1. Rigid State-wide definitions of "tolerable pollution" appear to be unsatisfactory as they are either too vague to permit accurate judicial interpretation or too rigid to permit reasonable enforcement. Administrative authority should be delegated to determine the degree of permissible pollution in any given body of water.

2. In the definition of "pollution", the jurisdiction of the State water pollution control agency should be made to extend to those discharges into waters of the State which may create a nuisance or be actually or potentially harmful and detrimental to public health, fish and aquatic life, or recreational, agricultural, industrial or other legitimate uses of water.

3. The definition of the term "person" should not be restrictive but should include the State, any municipality, county, sanitary district, public or private corporation, copartnership, firm or other entity or individual.

PRESERVATION OF EXISTING RIGHTS AND REMEDIES

A provision should be included to preserve existing legal remedies and safeguards against injuries, actual or threatened, due to water pollution. Such a provision could read:

> "It is the purpose of this Act to provide additional and cumulative remedies to prevent, abate and control the pollution of the waters of the State. Nothing herein contained shall be construed to abridge or alter rights of action of remedies in equity or under the common law or statutory law, criminal or civil, nor shall any provision of this Act, or any act done by virtue thereof, be construed as estopping the State, or any municipality or person, as riparian owners or otherwise, in the exercise of their rights in equity or under the common law or statutory law to suppress nuisances or to abate pollution."

SEVERABILITY

A severability clause should be included to provide that if any part of the statute is declared unconstitutional, the other parts shall not thereby be effected.

APPENDIX "E" (Continued)

CONSTRUCTION AND FINANCING OF SEWERAGE CONSTRUCTION

It is reported that additional legislation is needed in many States to enable municipalities to take full advantage of the loan provisions of the Federal Water Pollution Control Act. The Federal Works Agency has drafted legislation suitable for each of the States where such legislation is desirable to facilitate municipal action for this purpose. Division counsel of the Bureau of Community Facilities of the Federal Works Agency, located in nine field offices of that Agency, are available to discuss such drafts with interested State officials.

APPENDIX "F"

STATISTICS ON ENTERIC DISEASES IN THE DENVER AREA

MEMORANDUM February 26, 1949

To : Dr. R. L. Cleere, Executive Director

From : Eleanor L. Richie, Statistician

Subject: Available statistics on enteric diseases in the Denver Area.

As requested at your recent conference with Mr. Carnahan of the United States Public Health Service, I have made a preliminary review of our statistics on enteric diseases in the Denver Area in recent years. In brief, the case facts as routinely reported and tabulated in the past are scanty, and the numbers of reported cases are too small to permit dependable analyses as to age groups, season, and possible sources of infection. The statistics on cases reported, 1945-1948, are shown on page 3; and those on deaths from enteric diseases, 1945-1947, are presented on page 4.

Three sources of supplementary information indicate the possibility of considerably greater incidence of enteric diseases in this area than has been shown by the routine reporting procedures in the past.

1. Newly Started Denver Health Department Enteric Disease Files - The Communicable Disease Control Division of the Denver Department of Health and Hospitals started, in October 1948, to keep a card register of all cases of enteric disease among Denver residents as shown by laboratory tests and reported to Dr. Ward L. Chadwick. The sources of his information are, primarily, Denver General Hospital, Children's Hospital, and follow-up of contacts of the known cases. From October through December 1948, 24 cases of bacillary dysentery and 1 case of amoebic dysentery were entered in the card register and reported to the State Department of Public Health, plus 5 cases of paratyphoid fever. Only 4 of the dysentery cases were those of infants under 2 years of age.

2. Probable Need for Increased Laboratory Follow-Up of Cases Reported Merely As "Diarrhea" or "Enteritis" - From informal discussions with Doctor Chadwick, it appears that, in some instances, cases vaguely reported as "diarrhea" or "enteritis" would be identifiable as bacillary dysentery or other diseases due to specific pathogens, if laboratory tests were made. Prior to the 1948 revision, the State Department of Public Health communicable disease regulations did not require reporting of "diarrhea" or of "enteritis" as such. Under the 1948 revision, reporting is required on "diarrhea of the newborn, epidemic." This term is defined as "diarrhea in the newborn up to three weeks of age,

APPENDIX "F" (Continued)

occurring in a hospital giving maternity service" and the condition is described. The tabulated statistics on reported cases indicate, however, that since 1946 some reports have been coded and tabulated merely as "diarrhea and enteritis" (see the table on page 3). You will note also (table on page 4) that some deaths also are coded and tabulated in this way, in accordance with the International List of Causes of Death and Joint Causes of Death, 1939 Revision.

3. Bacillary Dysentery Outbreak at Lowry Field, September 1944. - The central laboratory of the State Department of Public Health cooperated with Lowry Field officials in investigating the cause of 250 cases of bacillary dysentery among the military personnel in September 1944. The cause of the outbreak was found to be raw cabbage, served as cole slaw, harvested from farms within a radius of 40 miles north of Denver where sewage contaminated water had been used for irrigation. Organisms of both the Paracolon and Shigella groups of bacteria were isolated in the laboratory examinations.

APPENDIX "F" (Continued)

SUMMARY OF AVAILABLE STATISTICS ON ENTERIC DISEASES AND FOOD POISONING DENVER AND SURROUNDING TRI-COUNTY AREA, 1945-1948

I. Cases reported to Epidemiology Section, State Department of Public Health

County & Year	Diar.and Ent.			Amoebic Dys.	Bacillary Dys.	Typhoid Fever	Paratyphoid	Food Poisoning
	All ages	-2	2+					
Denver:								
1945......	*	*	*	3	5	3	6	0
1946......	9	*	*	5	3	2	5	*
1947......	0	*	*	1	1	2	5	0
1948......	0	*	*	1[a]	24[b]	0	5[c]	44[d]
Adams:								
1945......	*	*	*	0	0	1	0	0
1946......	1	*	*	0	0	1	1	*
1947......	0	*	*	0	0	0	0	0
1948......	0	*	*	0	1	1	0	0
Arapahoe:								
1945......	*	*	*	0	1[e]	0	0	0
1946......	0	*	*	1	0	2	0	*
1947......	0	*	*	0	0	1	0	0
1948......	0	*	*	0	0	0	0	0
Jefferson:								
1945......	*	*	*	0	0	0	0	0
1946......	1	*	*	1	1	1	0	*
1947......	0	*	*	0	1	3	0	0
1948......	0	*	*	0	0	1	0	0

* Item not shown on report used. Regulations prior to 1948 did not require reporting. 1948 Revision of regulations requires reporting of epidemic diarrhea of the newborn up to 3 weeks of age.

[a] In Census Tract 26.

[b] One case each in Census Tracts 6, 7, 8, 12, 18, 19, 24, and 35; 2 cases in Tract 22; 3 cases each in Tracts 15, 17, and 20; 5 cases in Tract 42. See also page 2.

[c] One case each in Census Tracts 8, 19, and 22; 2 cases in Tract 24.

[d] One case in Census Tract 22; 3 cases in Tract 27; and 40 military cases in Tract 93 (Lowry Field), staphylococcus poisoning.

[e] See page 2 for notes on a 1944 outbreak of bacillary dysentery at Lowry Field.

APPENDIX "F" (Continued)

II. Deaths allocated to county of residence without adjustment for length of stay in county of death.

County and Year	Diar.and Ent.			Amoebic	Other	Typhoid	Para-	Food Poisoning
	All ages	-2	2+	Dys.	Dys.	Fever	typhoid	ing
Denver:								
1945.....	31	21	10	0	0	0	0	1[a]
1946.....	19	11	8	0	0	0	1	0
1947.....	20	15	5	1-	1[b]	0	0	0
1948.....	*	*	*	*	*	*	*	*
Adams:								
1945.....	9	8	1	0	0	0	0	0
1946.....	0	0	0	0	0	0	0	0
1947.....	0	0	0	0	0	0	0	0
1948.....	*	*	*	*	*	*	*	*
Arapahoe:								
1945.....	1	1	0	0	0	0	0	0
1946.....	1	1	0	0	1[c]	0	0	0
1947.....	2	1	1	0	0	0	0	0
1948.....	*	*	*	*	*	*	*	*
Jefferson:								
1945.....	5	2	3	0	0	0	0	0
1946.....	0	0	0	0	0	0	0	0
1947.....	5	1	4	0	0	0	0	0
1948.....	*	*	*	*	*	*	*	*

[a] Botulism

[b] Unspecified type

[c] Bacillary

III. Laboratory tests, Central Bacteriological Laboratory, State Department of Public Health

Very few specimens are submitted to this laboratory from the Denver Area. The records of test results for 1948 show only one positive specimen in the enteric group submitted from the Denver Area.

APPENDIX "G"

PARTIAL REVIEW OF LITERATURE ON PUBLIC HEALTH ASPECTS OF IRRIGATION WITH SEWAGE POLLUTED WATER

1. Davidson (1), according to Wilson (9), reports an outbreak of typhoid and paratyphoid fever involving 65 cases in North Battleford, Saskatchewan, Canada, during the summer of 1941. Neither milk nor water could be incriminated as the agent of transmission. Inconclusive evidence indicated that the infection was spread by vegetables which were irrigated, and possibly washed, with water from a ditch into which the sewage works discharged its effluent.

2. Chapman (2), stresses the need for treatment of sewage discharged to streams from which water is taken to irrigate market produce. Investigations conducted by the Colorado State Board of Health have shown that vegetables, grown in fields many miles below the source of the pollution, contained large numbers of colon bacilli. In many instances washing could not make them fit for human consumption. Some epidemiological evidence is presented. The death rate for typhoid fever, also for diarrhea and enteritis in infants up to 2 years of age, in Colorado is high when compared to that for the U. S. and several other western states. Colorado counties having polluted waters have death rates for the above infections almost twice those of counties in which there is little or no pollution of streams. Maps are presented which show the grossly polluted streams are closely associated with the counties having these higher death rates. Water and milk were not considered the infection source. It was recommended that fruits and vegetables grown under or close to the ground should not be irrigated with sewage polluted water. Although cooking may make eating such vegetables safe, it does not eliminate the possibility of introduction of infectious matter into the kitchen and its transfer to foodstuffs.

3. Lumsden and Anderson (3), in their investigation of the origin and prevalence of typhoid fever in the District of Columbia, found (3a) "a suggestively large portion of the typhoid cases in the District of Columbia had eaten lettuce, celery or strawberries during the 30 days prior to illness." They experienced difficulty in tracing the produce back to its source and therefore considered definite conclusions "not justifiable". They conclude (3b), however, that "In view of the insanitary conditions, particularly in respect to the lack of sanitary privies on farms which supply a large portion of the green vegetables and fruits distributed in Washington, it seems quite probable that those foodstuffs play some part, and for occasional periods perhaps a very considerable part, in the distribution of typhoid-fever infection in the District of Columbia". Furthermore, they recommend (3c), "The enactment of legislation prohibiting the sale or the offering for sale in the District of Columbia of ... any green garden truck obtained from farms not provided with either sanitary privies or sanitary water-closets".

4. Bundsen (4), reports that following a typhoid outbreak in Chicago, which was eventually traced to oyster infection, special effort was made

to determine the sources of certain vegetables, lettuce and watercress, served in hotels and restaurants, where it appeared the majority of cases had contracted the infection. This was found to be impossible, there was no common source for such produce. In connection with the investigation bacteriological examination of fruits, vegetables and watercress were undertaken. E.coli bacteria were found but whether of human or other source was not determined. In one case high coli contamination of lettuce was traced to the ice in which it was packed. Need for greater attention to watercress is stressed. In the discussion of Bundsen's paper Dr. F. C. Johnson, a pediatrician, comments that based on his experience he has "advised not to feed lettuce or celery to children as the possibility of infections being carried by these raw vegetables is really great."

5. In the discussion (5) of Dr. Warrys report of an outbreak of enteric disease involving 110 cases in the borough of Hackney, England, it is noted that a high per cent of the cases had partaken of watercress within 3 weeks prior to the illness, and bacteriological examination of beds from which the watercress had been taken showed the presence of sewage organisms, in one case, as high as 50 E. coli bacteria per cubic centimeter of water.

6. An article in the Journal American Medical Association (6) notes the raising of vegetables, frequently eaten raw, on the Paris, France sewage farm and associates the occurrence every year, from July to October, of typhoid fever in Paris with the marketing of these vegetables. "Clauditz found germs, after several days, on green herbs thus treated which a thorough washing could not remove. Dr. E. Marchoux, after an investigation, 'recommended that the kinds of herbs and vegetables that may be grown on sewaged land be established by law.'"

7. The American Society of Civil Engineers' committee on salvage of sewage (7) notes that in 1934 the directors of public health in each of the 48 states and the District of Columbia were asked for information on the extent of sewage use for irrigation. Only 9 states, of the 40 replies received, admitted having experience with sewage irrigation and sewage irrigated crops. Significantly, "four were able to trace illness of an epidemic order to such use, whereas one other stated that cattle, pastured on a raw sewage irrigated field developed poorly and were infested with Cysticercus bovis". At that time (7a) "Only one of the nine was agreeable to the use of (sewage) treatment plant effluent on vegetables to be eaten raw", and that state prescribed practically potable water standards for such effluent. In summarizing the committee states (7b) "Thus it would appear that, except for use upon vegetables to be eaten raw, an effluent from about that afforded by subsidence, trickling filters, and secondary subsidence effecting about 85% reduction in biochemical oxygen demand (B.O.D.) and suspended solids, followed by chlorination, should satisfy health requirements ..."

8. Roberts (8) noted 23 of 45 cattle fattened on the Tucson, Arizona, sewage farm were upon slaughtering found infested with the tape worm,

APPENDIX "G" (Continued)

Cysticercus bovis. Since these cattle apparently came from different sources - they all bore different brands - and such general infestation indicated a source common to all or most of them, it was concluded that the infestation resulted from drinking sewage polluted water.

9. Wilson (9) cites the experience at the Melborne, Australia, sewage farm where in 1937, 46% of the cattle grazed were found infested with Taenia saginata. The sale of these cattle was banned. During a six month survey of Melborne (1941-42) 100 cases of human tape worm infections were treated. He concludes, "In ... any town where large portions of the inhabitants are infested with tapeworm ... sewage and sewage sludge must present a real danger."

10. Under Annotations (10) it is noted that Leptospirosis is essentially an occupational disease. Human infection is acquired through the alimentary tract or by contact with contaminated water or other material. It has occurred "during the last few years among ... sewer workers in London and Glasgow ..., and workers in the beet fields in Ireland, who are probably infected through abrasions of the hands in the same way as are the sugar cane cutters in Queensland".

11. Mills et al. (11) conducted laboratory investigations to determine whether the bacteria penetrated the surface of fruits and vegetables. They found that although bacteria do not penetrate the uninjured surface, they may gain entrance through damaged or decayed surfaces and remain viable for from 7 to 42 days. They also demonstrated that bacteria may persist on the surface of fruits or vegetables kept moist for 15 or more days.

12. Klinger (12) investigated the survival and dispersion of typhoid and dysentery bacilli in soil. These bacteria were recoverable from artificially inoculated moist soil (pH 6.6-7.4) for 70 or more days, but were not recoverable in dry soil on the 20th day. They penetrated to a depth of 2, but not 3, feet in 40 days in relatively porous soil under a 1 to 2 inch head of water.

13. Melick (13) in three outdoor experiments, extending from May to September, isolated typhoid bacteria from garden soil 41, 34 and 35 days after inoculation with typhoid bearing excreta. Under hot house conditions old strains of typhoid bacteria survived for 74 days in garden soil enriched with sterile sewage; fresh strains survived only 49 days. In these experiments typhoid bacteria were found on radishes grown in infected soil 37, 28 and 35 days, and on lettuce after 21 days, after inoculation of the soil. The organism became attached to the surface and was not ordinarily removable by washing.

14. Creel (14) investigated the viability of typhoid bacilli on garden truck. He reports 3 experiments in which radishes and lettuce were raised on soil sprinkled with a fecal emulsion mixed with 24-hour old culture of typhoid bacilli 2 or 3 days after the planting.

APPENDIX "G" (Continued)

He states, "that plants cultivated in contaminated soil will take up on the leaves and stems, as they grow through the soils, organisms existing therein."

"The Bacillus typhosus (typhoid bacillus) was recoverable from the tips of leaves that were, to the naked eye, free from soil" and that when these vegetables were grown under natural conditions (except for the artificial inoculation of the soil) the infectious material could be isolated from the leaves up to 31 days.

"Rainfall will not free the vegetables from the infected material".

15. According to Melick (13) "Morse (15) attributed 49 typhoid cases among inmates of an insane asylum to the eating of celery." Typhoid cases had occurred in the institution a few months previously, the celery bed received the institutions sewage, and the epidemic occurred soon after the first use of the celery.

16. According to Melick (13) "Picley (16) records 2 cases of typhoid from eating uncooked rhubarb, which was grown on soil known to be fertilized with typhoid bearing excreta."

17. Veatch (17a) in discussing the Denver, Colorado sewage disposal problem notes that on certain days the Denver sewage accounts for 97% of the flow of the South Platte River, which is used for irrigation immediately downstream. He refers to the construction at Denver in 1937 of a sewage treatment plant which included "fine grained rapid sand filters to secure a high rate of removal of suspended solids and incidentally the removal of ... the encysted type of amoeba (Endamoeba histolytica) which is strongly suspected of being responsible, through the medium of sewage irrigated vegetables, for a considerable amount of sickness in this area." (Abstractor's note: The magnetite filters referred to did not operate satisfactorily and their use was discontinued.)

18. Tanner (18) points out that missed cases and carriers may always be present and that sewage should always be regarded as containing infectious organisms. The work of several investigators is cited and Tanner concludes that (18a) "Sufficient data ... have been recorded to justify the conclusion that polluted soil may infect vegetables grown on it." He adds (18b) that "good epidemiological evidence seems to exist in the literature to the effect that fresh vegetables may and have caused communicable diseases and that the sanitary condition of the soil from which they are harvested is important." - and finally (18c) that "This review of the literature quite clearly indicates that fresh vegetables which are raised on polluted soil may transmit pathogenic bacteria."

19. Rider (19) in commenting on irrigation in Arizona notes the insanitary practices of many camps of agricultural workers and the use of the main canals for drinking water, swimming, washing clothes, etc. In spite of such conditions only a few instances were noted where water borne diseases

APPENDIX "G" (Continued)

were attributed to canal water. Several years ago, as the result of a newspaper syndicated article, the state laboratory, undertook bacteriological examination of lettuce. Many heads - from 16 fields in the Salt River Valley and from two in the Eloy district - were cultured but no evidence of typhoid or allied organisms was found. Although the technique used was rather hastily devised, it was felt any general contamination would have been indicated.

20. The Committee on Sewage Disposal, American Public Health Association (20) notes in 1937, that "California, alone, out of 33 states reporting, ... has adopted regulations under its Public Health Act whereby the disposal of sewage, sewage effluent or sludge for irrigation or fertilizing purposes" requires a permit from the State Board of Health. Briefly these California Regulations require that raw sewage shall not be used for irrigating growing crops, and settled or undisinfected sewage is banned for the irrigation of growing vegetables, garden truck, berries, or low-growing fruit, or for watering vineyards or orchards where windfalls or fruit lie on the ground.

21. The Committee on Utilization of Sewage Sludge as Fertilizer, Federation of Sewage Works Associations, in their report (21) in 1942, notes the California regulations are still in effect. Several other states regulate or advise regarding use of sewage sludge.

22. Rawn (22) notes that as of June, 1934, 39 states and the District of Columbia had replied to a questionnaire on use of sewage for irrigation. Thirty states reported neither sewage nor sewage-polluted waters were used for irrigation within their boundaries. Seventeen of these states reported they would not tolerate such use, and the other 13 found it repugnant.

"In the 9 states which admitted use of sewage for irrigation, the attitude was one of tolerance ... and rigid regulation of the production of the effluent as well as the nature of the crops for which it was to be used."

23. DeMartini (23) mentions the following regulations concerning irrigation with sewage and sewage-laden waters:

(1) Colorado - "Requires written permission of State Board of Health for use of sewage or sewage-polluted waters when Coli-aerogenes group of bacteria exceeds 10 per cc."

(2) California and Oregon - "Prohibit use of raw sewage for irrigating growing crops. Prohibit use of settled or undisinfected sewage effluents on growing vegetables and garden truck. Highly oxidized and disinfected sewage effluents can be used provided they meet drinking water standards in Oregon and in California if not over 10% of 10cc. portions are positive for the Coli-aerogenes

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group. Also no single sample can be positive for over half of the 0.1 cc. portions examined."

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